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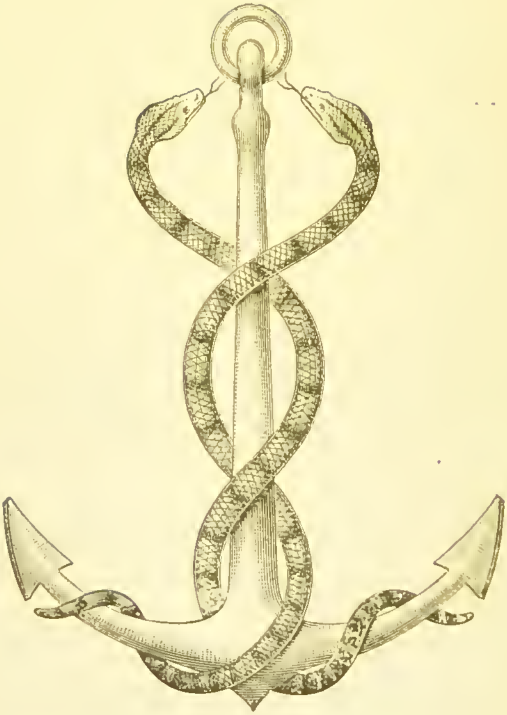

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MANUAL OF SURGERY

BY

ALEXIS THOMSON, M.D., F.R.C.S.Ed.
ASSISTANT SURGEON EDINBURGH ROYAL INFIRMARY; SURGEON TO THE
DEACONESS HOSPITAL, EDINBURGH

AND

ALEXANDER MILES, M.D., F.R.C.S.Ed.
ASSISTANT SURGEON EDINBURGH ROYAL INFIRMARY;
SURGEON TO LEITH HOSPITAL

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PREFACE.

In the preparation of this work we have endeavoured to furnish a systematic view of the present-day aspects of Surgery in sufficient detail to render it useful to the practitioner, without at the same time carrying it beyond the scope appropriate to a Manual for Students.

We have curtailed as far as possible the discussion of theoretical and debatable matter, and have only described pathological processes in so far as they bear directly on diagnosis and treatment. We have not considered it advisable to describe or illustrate histological appearances, as these are more appropriately dealt with in a textbook of Pathology.

The description of the Injuries and Diseases of individual tissues and organs have been arranged with a view to facilitate clinical study, and with the same object a brief resumé has been given of the Surgical Anatomy of the tissue or region concerned.

With a few exceptions the illustrations are original, and appear in these pages for the first time. To our colleagues in the Edinburgh School, and to our other friends who have so generously aided us in this matter, we desire here to tender our sincere thanks.

We would also acknowledge our indebtedness to Sir William Turner for permission to photograph specimens in the Anatomical Museum of the University of Edinburgh; and to the Museum Committee of the Royal College of Surgeons of Edinburgh for a similar privilege. Those illustrations not otherwise acknowledged are from drawings or photographs in our own collections. We have not considered it necessary to introduce illustrations of surgical instruments.

Our thanks are due to Dr. Logan Turner for his contributions on the affections of the Ear, Nose, and Larynx; and to Dr. Thomas D. Luke for the section on Anæsthetics.

EDINBURGH, *January* 1904.

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MANUAL OF SURGERY

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MANUAL OF SURGERY.

CHAPTER I.

REPAIR.

Introduction—The ideal process of repair—Modifications of ideal process —Repair in individual tissues.

Introduction.

To prolong human life and to alleviate suffering are the ultimate objects of scientific medicine. The two great branches of the healing art—Medicine and Surgery—are so intimately related to one another that it is impossible to draw a hard and fast line between them. For convenience, however, Surgery may be defined as "the art of treating lesions and malformations of the human body by manual operations, mediate and immediate." In order to apply his art it is essential that the surgeon should be thoroughly conversant with the normal anatomy of the body, and with the various pathological processes to which it is liable. Without this knowledge he is unable to recognise such deviations from the normal as result from mal-development, injury, or disease, or rationally to direct his efforts towards the correction or removal of these. And, further, it is not only necessary that the surgeon should be familiar with the various morbid conditions met with in the body, but he must also understand the methods by which nature brings about the repair of these conditions. For it must never be forgotten that the repair of living tissues is a natural and spontaneous process which tends to go on to perfection, except in so far as it is interfered with by external agencies. The *rôle* of surgery, then, being to correct or remove such extraneous influences as tend to interfere with natural reparative processes, it is essential that at the outset we should clearly understand the natural process of repair in order that our efforts may be directed in harmony therewith.

PROCESS OF REPAIR.

The Ideal Process of Repair: Healing by Primary Union.—The ideal process of natural repair can best be studied as it occurs in a clean-cut wound of the integument, uncomplicated by loss of tissue or by the presence of foreign substances, and more particularly of disease-producing micro-organisms. Such a wound, in virtue of the absence of organisms, is said to be *aseptic*, and furnishes the most favourable conditions possible for the reparative process.

Formation of Granulation Tissue.—The passage of the knife through the tissues is immediately followed by an oozing of blood from all the divided vessels, which soon coagulates on the cut surfaces. If the wound be now closed, the narrow space between its edges is occupied by blood-clot, which consists of red and white corpuscles mixed with a quantity of fibrin, and which forms a temporary uniting medium between the divided surfaces. In the course of a few days the capillaries of the part adjacent to the wound begin to dilate, and throw out minute buds and fine processes which bridge the gap, and so form a firmer, but still temporary, connection between the two sides. Each bud begins as a small accumulation of granular protoplasm in the wall of the capillary, and gradually elongates into a filament containing a nucleus. This filament either joins with a neighbouring capillary or with a similar filament, and in time these become hollow and are filled with blood from the vessels which gave them origin. In this way a series of young *capillary loops* is formed, the spaces between which are filled by large, irregular, nucleated cells, derived from the proliferation of the fixed connective tissue cells of the part, and from the endothelial lining of the newly formed vessels. As these cells are concerned in the production of fibrous tissue they are known as *fibroblasts*. Large multi-nucleated *giant cells* may also be found amongst the fibroblasts, especially if any foreign body, such as a silk ligature, is embedded in the tissues.

Wandering leucocytes, too, are present in the spaces between the capillary loops, but take no direct part in the formation of the new tissue. Their function seems to be the removal of the red corpuscles and fibrin of the original blood-clot, and this performed, they either pass back into the circulation in virtue of their amœboid movement, or are themselves eaten up by the growing fibroblasts.

These young capillary loops, with their supporting cells and fluids, constitute *granulation tissue*, which must be looked upon as the fundamental and invariable basis of all tissue repair.

Formation of Cicatricial Tissue.—This temporary granulation tissue subsequently becomes more fibrous and less cellular in character as it is transformed into *young cicatricial or scar tissue*. The fibroblasts become enlarged, rounded, and finally spindle-shaped, and produce a fibrillated substance around them which gradually increases in amount and develops into white fibrous tissue. This fibrous tissue assumes an arrangement depending upon the mechanical pull or pressure which happens to be put upon the part. At the same time the capillaries become narrowed and also less numerous.

While these changes are taking place this cicatricial tissue is being covered over by *epidermis* from the margins of the wound. The cells of the rete Malpighi close to the cut edge sprout on to the surface of the wound, and by their proliferation cover the granulations with a thin pink pellicle. As the epithelium increases in thickness at the periphery it assumes a bluish hue, and eventually the cells become cornified and of a greyish white colour.

In course of time the newly-formed connective tissue undergoes *cicatricial contraction* by the diminution in size of the blood-vessels and cells and by the consolidation of the young white fibrous tissue.

The process of ideal repair being unassociated with inflammation, goes on without any appreciable interference with the general health of the patient. The temperature remains normal. The circulatory, gastro-intestinal, nervous, and other functions are undisturbed; while locally, the part is cool, of natural colour, and free from pain.

This natural process of repair has long been known as "healing by first intention." It takes place without artificial aid from the surgeon, so long as the edges of the wound are in apposition and extraneous sources of irritation are excluded. Its progress is not attended by any of the phenomena of inflammation. It is the type of all reparative processes, the various clinical modifications differing from it only in degree. Reparative processes complicated by extraneous agencies such as sepsis, show further phenomena which will be considered later.

Modifications of the Process of Repair.—*Reunion of Parts entirely Separated from the Body.*—Small portions of tissue, such as the end of a finger, the tip of the nose, or a portion of the external ear, completely separated from the body, if accurately replaced and fixed in position occasionally adhere by primary union.

Healing under a Scab.—When a small superficial wound is exposed to the air, the blood and serum exuded on to its surface sometimes dry, and form a hard crust or *scab*, which may serve to protect the surface from external irritation. Under this scab the formation of granulation tissue, its transformation into cicatricial tissue and the growth of epithelium on the surface, go on uninterruptedly, until in the course of time the crust separates, leaving a healthy scar.

Healing by Blood-clot.—Under many circumstances, such as in subcutaneous wounds, amputation wounds, wounds made in excising tumours or in operating upon bones, it is impossible accurately and completely to approximate the divided surfaces. The result is that the space left becomes filled with blood-clot, which acts as a temporary scaffolding in which granulation tissue is built up. Capillary loops grow into the coagulum, and migrated leucocytes from the adjacent blood-vessels destroy the red corpuscles, and are in turn destroyed by the developing fibroblasts, which by their growth and proliferation fill up the gap with young connective tissue. It will be evident that this process only differs from healing by primary union in the *amount* of blood-clot which is present.

Repair after Loss or Destruction of Tissue.—When no attempt towards approximation of the edges of a wound can be made either because a considerable portion of tissue has been lost, for example, in excising a tumour implicating the skin, or because of the presence in the wound of a foreign body, such as a drainage-tube or a pad of gauze, the healing process is somewhat modified.

A much greater amount of new tissue is required to fill up the gap,—although the process by which this is produced is essentially the same as in the ideal method of repair—namely, the formation of granulation tissue, and its transformation into young fibrous tissue.

The raw surface is first covered by a layer of coagulated blood and fibrin. An extensive new formation of capillary loops and fibroblasts takes place towards the free surface, and goes on until the gap is filled by a fine velvet-like mass of granulation tissue, and then the process tends to stop. This granulation tissue is gradually replaced by young cicatricial tissue, and the surface is covered by the ingrowth of epithelium from the edges of the skin. This modification of the reparative process can be well studied clinically in a wound which, at the time of the operation, has been packed with gauze. When the plug is introduced the walls of the cavity consist of raw tissue with numerous oozing blood-vessels. On removing the stuffing on the fifth or sixth day, it is found that the surface is covered with minute, red, papillary projections (*granulations*), and that already the cavity has become smaller, having been filled in from below by these velvet-like growths. At the edges, too, the epithelium has proliferated and is covering over the newly formed tissue. On subsequently examining the wound at intervals of a few days, it is found that the granulation tissue gradually increases in amount till the gap is completely filled up, and that coincidently the epithelium spreads in and covers over its surface. In course of time the epithelium thickens, and as the granulation tissue is slowly replaced by young cicatricial tissue, which has a peculiar tendency to contract, and so to obliterate the blood-vessels in it, the scar which is left becomes smooth, pale, and depressed. This method of healing is sometimes spoken of as "healing by granulation"—although, as we have seen, it is by granulation that all repair takes place.

Healing by Union of two Granulating Surfaces.—In widely-gaping wounds closure is sometimes obtained by bringing the two surfaces into apposition after each has become covered with healthy granulations. The serum effused on the surfaces causes them to adhere, capillary loops pass from one to the other, and their final fusion takes place by the further development of granulation and cicatricial tissue.

REPAIR IN INDIVIDUAL TISSUES.

Having studied the process of repair in general, it will obviate unnecessary repetition later if the modifications of that process as seen in the regeneration of certain of the individual tissues be now considered. Nature's efforts are always directed towards effecting a complete and perfect restitution to the normal, but her success varies with the tissue involved and the amount of damage which it has sustained. Any given tissue can only be replaced from tissue of a similar kind; but while simple structures such as skin, cartilage, bone, periosteum or tendon, have a high power of regeneration, those of a more complex organisation, such as secreting glands, muscle, and the tissues of the central nervous system, are but imperfectly restored. The peripheral nerves, however, are eminently capable of regeneration.

The elementary basis of all repair is granulation tissue. If any portion of the original structure survive, this granulation tissue is replaced by an imitation of the original tissue, more or less perfect in proportion to the simplicity of its constituent elements. Where the original tissue is completely destroyed, or is of a highly-specialised structure, simple cicatricial connective tissue fills the gap, or a cavity filled with a turbid fluid may persist.

Regeneration of Skin and Connective Tissue.—The mode of regeneration of these tissues has already been described as the type of ideal repair. The more highly-organised elements of the skin, such as hair follicles, sweat and sebaceous glands, are not reproduced ; hence a superficial scar remains, smooth, dry, and hairless.

Regeneration of Epithelium.—Epithelium is only reproduced from pre-existing epithelium, and, as a rule, from one of a similar type, although metaplastic transformation of cells of one kind of epithelium into another kind can take place. Thus a granulating surface may be covered entirely by the ingrowing of the cutaneous epithelium from the margins ; or islets may spring up in the centre of the raw area, originating in surviving cells of sebaceous glands or sweat glands, or of hair follicles. Such islets may also be due to the accidental transference of loose epithelial cells from the edges. Even the fluid from a blister, in virtue of the isolated cells of the rete Malpighi which it contains, is capable of starting epithelial growth on a granulating surface. Hairs and nails may be completely regenerated if a sufficient amount of the hair follicles or of the nail matrix has escaped destruction. The epithelium of a mucous membrane is regenerated in the same way as that on a cutaneous surface.

Epithelial cells have the power of living for some time after being separated from their normal surroundings, and of growing again when once more placed in favourable circumstances. On this fact the practice of skin-grafting is based.

Repair of Tendons.—When a tendon is divided the end nearer the muscle fibres is drawn away from the other, leaving a gap which is speedily filled by blood-clot. In the course of a few days this clot becomes permeated by granulation tissue, the fibroblasts of which are derived from the sheath of the tendon, the surrounding connective tissue, and probably also from the divided ends of the tendon itself. These fibroblasts ultimately develop into typical tendon cells, and the fibres which they form constitute the new tendon fibres. In the course of this reparative process it is not uncommon for the tendon and its sheath to become adherent, leading to impeded movement and stiffness.

Repair of Cartilage.—Solutions in continuity of cartilage are usually repaired by ordinary cicatricial fibrous tissue. This takes place, for example, when a portion of articular cartilage is divided by incision or by a fracture implicating the articular end of a bone.

In other cases, such as in fractures of costal cartilage or of the cartilages of the larynx, the cicatricial tissue is ultimately replaced by bone.

It is, however, possible for a metaplastic transformation of connective-tissue cells into cartilage cells to take place, the characteristic hyaline matrix being secreted by the new cells. This is sometimes observed as an intermediary stage in the healing of fractures, especially in young bones. It may also take place in the regeneration of lost portions of cartilage, provided the new tissue is so situated as to constitute part of a joint and to be subjected to pressure by an opposing cartilaginous surface. This is illustrated by what takes place after excision of joints where it is desired to restore the function of the articulation. By carrying out passive movements between the constituent parts, the fibrous tissue covering the ends of the bones becomes moulded into shape, its cells take on the characters of cartilage cells, and forming a matrix, so develop a new cartilage.

Conversely it is observed that when articular cartilage is no longer subjected to pressure by an opposing cartilage, it becomes transformed into fibrous tissue, as may be seen in deformities attended with displacement of articular surfaces, such as hallux valgus or club-foot.

Repair of Bone.—The repair of bone is most conveniently considered in relation to fractures, but the steps in the process are practically identical when the bone has been divided in the operation of osteotomy, in resection or excision.

Repair of Muscle.—Neither unstriped nor striped muscle seems to be capable of being regenerated to any but a moderate degree. If the ends of a divided muscle be at once brought into apposition by stitches, primary union takes place with a minimum of intervening fibrous tissue. The nuclei of the muscle fibres in close proximity to this young cicatricial tissue proliferate, and a few new muscle fibres may be developed, but any gross loss of muscular tissue is replaced by a fibrous cicatrix. It would appear that portions of muscle transplanted from animals to fill up gaps in human muscle are similarly replaced by fibrous tissue. When a muscle is paralysed from loss of its nerve-supply and undergoes complete degeneration, it is not capable of being regenerated, even should the integrity of the nerve be restored, and so its function is permanently lost.

The *Repair of Blood-vessels* is described at p. 240.

Regeneration of Secretory Glands.—The regeneration of secretory glands, such as the salivary glands, liver, and kidney, is very incomplete. The greater part of any gap left in such organs is filled by cicatricial tissue, but in some, for example, the liver and kidney, the epithelial cells of the remaining glandular tissue proliferate, and a certain degree of regeneration takes place.

Regeneration of Intestine and other Composite Structures.—Composite structures like the intestine, the œsophagus, the bladder, or the urethra, are repaired by the formation of cicatricial tissue, each constituent element behaving after the manner of its kind. Thus the muscular and glandular tissues are not reproduced, while the fibrous, vascular, and lining epithelial elements are.

Regeneration of Nerve Tissues.—There is no trustworthy evidence that regeneration of the tissues of the brain or spinal cord in man ever takes place. Any loss of substance is replaced by cicatricial tissue.

The Regeneration of Peripheral Nerves is described at page 313.

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CHAPTER II.

CONDITIONS WHICH INTERFERE WITH REPAIR.

Want of rest—Irritation—Unhealthy tissues—Pathogenic bacteria. SURGICAL BACTERIOLOGY—Introduction—General characters of bacteria—Classification of bacteria—Conditions of bacterial life—Pathogenic powers of bacteria—Results of bacterial growth—Death of bacteria—Immunity—Antitoxic sera—Bacteriological diagnosis—Pyogenic bacteria. LEUCOCYTOSIS. THE TEMPERATURE IN SURGICAL DISEASES.

THE general process of ideal repair, and its modifications in the regeneration of the different tissues which have been studied, are liable to be interrupted or completely arrested by various extraneous influences, which it is the duty of the surgeon to prevent or remove.

Of such conditions the first is *Want of Rest.* "The first and great requisite for the restoration of injured parts is rest," said John Hunter; and physiological and mechanical rest as the chief of natural therapeutic agents was the theme of John Hilton's classical work. By "rest," in this connection, is meant not merely a state of physical repose, but in addition as complete cessation of all physiological and mechanical function as is possible. A tuberculous joint, for example, must be enclosed in splints in such a way as to prevent all movement of its constituent bones. An inflamed eye must be protected from the light, in addition to having its movements arrested. Before a small ulcer of the mucous membrane of the anus (anal fissure) will heal, it is not only necessary to prevent the mechanical stretching of the part due to the periodic movement of the bowels, but the persistent contractions of the underlying sphincter muscle may require to be arrested by stretching or cutting its fibres.

Another fertile source of interference with repair in surgical wounds is *irritation*, either by mechanical agents such as rough, unsuitable dressings, bandages, or ill-fitting splints; or by chemical agents in the form of strong lotions or other applications.

An *unhealthy or devitalised condition of the patient's tissues* also hinders the reparative process. Bruised or lacerated skin heals less kindly than skin cut with a smooth, sharp instrument. Venous congestion of a part, such as occurs in the leg when the veins are varicose, or the existence of grave constitutional disease, such as Bright's disease, diabetes, syphilis, scurvy, or alcoholism, also impedes healing.

Infection by disease-producing micro-organisms, or *pathogenic bacteria*, is, however, the most potent factor in disturbing the natural process of repair in surgical wounds.

SURGICAL BACTERIOLOGY.

Within recent years the whole science of pathology has been revolutionised by the knowledge which has accumulated regarding the nature of micro-organisms, and their relation to disease. So much has bacteriology come to dominate every department of surgery in particular, that it is now the standpoint from which nearly all surgical questions have to be considered. In no department of medical science has so much progress been made, or such a wealth of information and literature arisen, in a corresponding period of time. It is therefore necessary that we should here confine our attention to such aspects of the subject as have a direct surgical bearing.

The term *sepsis* as now used in clinical surgery no longer retains its original meaning as synonymous with "putrefaction," but is used to denote all conditions in which bacterial infection has taken place, and more particularly those in which pyogenic bacteria are present. In the same way the term *aseptic* conveys the idea of freedom from all forms of bacteria, putrefactive or otherwise; and the term *antiseptic* is used to denote a power of counteracting bacteria and their products.

General Characters of Bacteria.—The term *bacteria* is employed in a generic sense to include all the forms of minute vegetative organisms of which the science of bacteriology treats, and is to be accepted as synonymous with such terms as micro-organisms, microbes, or germs.

A *bacterium* consists of a finely granular mass of protoplasm, enclosed in a thin gelatinous envelope. Many forms are motile some in virtue of fine thread-like flagella, and others through contractility of their protoplasm. The great majority multiply by simple fission, each parent cell giving rise to two daughter cells, and this process goes on with such extraordinary rapidity that it has been computed that in twenty-four hours from one individual bacterium seventeen millions of similar cells may be produced. Other varieties are propagated by the formation of *spores*, but as most spore-forming bacteria give rise to only one spore, this is rather a process of rejuvenescence than of multiplication. A spore is a minute mass of protoplasm surrounded by a dense, tough membrane, developed in the interior of the parent cell. Spores are remarkable for their extreme vitality, and for the resistance they offer to the action of heat and chemical germicides.

Bacteria are most conveniently classified according to their shapes. Thus we recognise (1) those which are globular—*cocci*; (2) those which resemble a straight rod—*bacilli*.

Cocci or micrococci are minute round bodies, averaging 1 to 1·5 mm. in diameter. They all multiply by fission, and when they divide in such a way that the resulting cells remain in pairs, they are called *diplococci*, of which the bacteria of gonorrhœa and pneumonia are examples. When they divide irregularly and form grape-like bunches they are known as *staphylococci*, and to this variety the commonest pyogenic or pus-forming organisms belong. When division takes place only in one axis, so that long chains are formed, the term *streptococcus* is applied. Streptococci are met with in erysipelas and various other inflammatory and suppurative processes of a spreading character.

Bacilli are rod-shaped bacteria, usually at least twice as long as they are broad. Some multiply by fission, others by sporulation. Tuberculosis, tetanus, anthrax, and many other surgical diseases are due to different forms of bacilli.

Conditions of Bacterial Life.—The first essential to the growth and development of bacteria is a suitable food-supply in the form of proteids and carbo-hydrates, which complex organic substances they break up, in the act of nourishing themselves, into simpler elements. An alkaline medium favours bacterial growth; and moisture is a necessary condition, although spores can survive the want of water for much longer periods than fully-developed bacteria. The necessity for oxygen varies in different species. Those which, like the bacillus proteus vulgaris, can only flourish in its presence, are known as *aërobic bacilli*, or *aërobes*; those, such as the bacillus of tetanus and of malignant œdema, which will not live in the presence of oxygen, are spoken of as *anaërobic*. The great majority of bacteria, however, while they prefer oxygen, are able to get on without it, and are called *facultative anaërobes.*

A temperature ranging from 95° to 102° F. is the most suitable for bacterial life. Extreme or prolonged cold paralyses but does not kill micro-organisms. Few, however, survive being raised to a temperature of 134½° F. Boiling for ten to twenty minutes will kill not only the bacteria, but even their most resistant spores. Direct sunlight, electric light, or even diffuse daylight is inimical to the growth of bacteria.

Pathogenic Properties of Bacteria.—We are now only concerned with pathogenic bacteria—that is, bacteria capable of producing disease in the human subject. This capacity depends upon two sets of factors—(1) certain features peculiar to the invading bacteria, and (2) others peculiar to the host. Many bacteria have only the power of living upon dead matter, and are known as *saprophytes.* Such as do flourish in living tissue are, by distinction, known as *parasites.* The power a given parasitic micro-organism has of multiplying in the body and giving rise to disease is spoken of as its *virulence*, and this varies not only with different species, but in the same species at different times and under varying circumstances. The actual number of organisms introduced is also an important factor in determining their pathogenic power. Healthy tissues can resist the invasion of a certain number of bacteria of a given species; but when that number is exceeded, the organisms get the upper hand, and disease results. It is also the case that if organisms gain access directly to the blood-stream they produce their effects more certainly and with greater intensity than when they are introduced into extra-vascular tissues.

Further, the virulence of an organism is modified by the condition of the patient into whose tissues it is introduced. So long as a person is in robust health the tissues are able to resist the attacks of moderate numbers of most bacteria. Any lowering of the vitality of the individual, however, either locally or generally, at once renders him more susceptible to infection. Thus bruised or torn tissue is much more liable to infection with pus-producing organisms than tissues clean-cut with a knife; also, after certain diseases, the liability to infection by the organisms of diphtheria, pneumonia, or erysipelas is much increased. Even such slight depression of vitality as results from bodily fatigue, or exposure to cold and damp, may be sufficient to turn the scale in the battle between the tissues and the bacteria. Age is an important factor in regard to the action of certain bacteria. Young subjects are attacked by diphtheria, tuberculosis, acute osteo-myelitis, and some other diseases with greater frequency and severity than those of more advanced years.

In different races, localities, environments, and seasons, the pathogenic powers of certain organisms, such as those of erysipelas, diphtheria, and acute osteo-myelitis, vary considerably.

There is evidence for the statement that a *mixed infection*—that is, the introduction of more than one species of organism—increases the severity of the resulting disease. Even if one of the varieties gain the ascendancy, the poisons produced by the others so devitalise the tissue cells, and diminish their power of resistance, that the virulence of the most active organism is increased. On the other hand, there is reason to believe that the products of certain organisms antagonise one another.

Lastly, it is not uncommon for micrococci and bacilli to invade the internal organs by the blood-stream in enormous numbers and with great rapidity during the period of extreme debility which shortly precedes death.

Results of Bacterial Growth.—Some organisms, such as those of tetanus, erysipelas, and some of the pyogenic bacteria, show little tendency to pass beyond the point at which they gain an entrance to the body. Others, on the contrary,—for example, the tubercle bacillus and the organism of acute osteo-myelitis,—although frequently remaining localised to the seat of inoculation, tend to pass to distant parts, lodging in the capillaries of joints, bones, kidney, or lungs, and there producing their deleterious effects.

Multiplication in the blood-stream does not occur to any great extent in man.

It is by the vital changes they bring about in the parts where they settle that micro-organisms disturb the health of the patient. In deriving their nourishment from the complex organic compounds in which they flourish, the organisms evolve, probably by means of a ferment, certain chemical products in the form of albumoses, peptones, alcohols, ethers, and acids ; as well as certain gases, such as sulphuretted hydrogen, carbonic acid, and marsh gas. These, and probably other more complex substances, the constitution of which is as yet unknown, are generically known as *toxins*. When these poisons are absorbed into the general circulation of the patient, they give rise to certain groups of symptoms—such as rise of temperature, associated circulatory and respiratory derangements, interference with the gastro-intestinal functions and also with those of the nervous system—which go to make up the condition known as blood-poisoning, toxæmia, or *bacterial intoxication.* In addition to this, certain bacteria produce toxins which give rise to definite and distinct groups of symptoms—such as the convulsions of tetanus, or the paralyses which follow diphtheria.

Local lesions also, of an inflammatory, suppurative, or ulcerative character, result from the action of certain organisms and their products, as in the case of tuberculosis, typhoid, anthrax and diphtheria.

Death of Bacteria.—Under certain circumstances it would appear that the accumulation of the toxic products of bacterial action tends to interfere with the continued life and growth of the organisms themselves, and in this way the natural cure of certain diseases is brought about. Outside the body bacteria may be killed by starvation, by want of moisture, by being subjected to high temperature, and by the action of certain chemical agents, of which carbolic acid and the perchloride and biniodide of mercury are the most powerful.

Immunity.—It has long been known that some individuals are insusceptible to infection by certain diseases, from which they are said to enjoy a *natural immunity.* It is also well established in the case of many acute diseases—it is probably true of all—that one attack protects the patient, for a time at least, from a second attack. This is known as an *acquired immunity.* Numerous attempts have been made to explain these facts, but it must at once be admitted that no one of them is as yet entirely convincing. The opinion of Pasteur that the necessary pabulum in the blood for the organisms becomes exhausted, and the view that the bacteria themselves produce substances inimical to their continued growth or subsequent reappearance, are equally insufficient. Metchnikoff's theory of *phagocytosis,* while it carries us further, does not afford a complete explanation of the phenomena. According to Metchnikoff, the phagocytes—leucocytes and connective-tissue corpuscles—have the power of taking into their interior the invading organisms, and so prevent the formation of their toxins. From the fact that this ingestion process goes on most actively in immunised animals it would appear that phagocytosis is rather a result than the cause of immunity. At the same time many facts have been established, which, if they do not constitute proof of any one theory, have at least resulted in certain highly useful and practical conclusions. The chief of these is that immunity from certain diseases may be produced by artificial inoculation with the products of the organisms which cause them.

Artificial immunity may be induced in one of two ways—(*a*) either by injecting into an animal a series of non-lethal doses of an organism or its toxins; or (*b*) by injecting the serum of an animal highly immunised by the previous method into a second animal. The latter is the principle on which the modern anti-toxin method of treatment is based, and it may act either against specific toxins, as in the case of the anti-diphtheric and the anti-tetanus sera (*antitoxic sera*), or against specific organisms, as in the anti-streptococcic serum (*anti-microbic sera*).

The *antitoxic serum* is produced by a process of which the following are the essential steps:—(1) a powerful toxin is obtained from artificial cultures of a highly virulent organism. (2) The power of this toxin is estimated by experimental injections into animals of known weight, until a standard of toxicity is obtained; (3) a large animal, for example, the horse, after being rendered immune by gradually increasing doses of this toxin, is bled aseptically, and the serum after separating is ready for use, 0·5 per cent of carbolic acid being added to prevent decomposition. (4) By experiments on animals the immunising value ("unit of immunity") of this serum is then obtained, and the clinical dose determined.

Clinical Use of Antitoxic Sera.—Each antitoxic serum has its own appropriate dose depending upon the value of its unit of immunity. Every precaution must be taken to prevent organismal contamination of the serum or of the apparatus by means of which it is injected. Syringes are so made that they can be sterilised by boiling. The best situations for injection are under the skin of the abdomen, the thorax, or the buttock, and the skin at the seat of puncture should be previously purified. If the bulk of the full dose is large, it should be divided and injected into different parts of the body, not more than 20 *c.c.* being injected at one place.

Bacteriological Diagnosis.—For purposes of diagnosis various facts regarding the morphology and life-history of bacteria are made use of. Thus by means of the microscope the general histological characters may be studied after staining with certain aniline dyes. Again, different organisms vary in their behaviour on such artificial culture-media as gelatin, agar-agar, bouillon, potato, etc., with regard to the rapidity and direction of growth; the colour and smell of the growing colonies; and the effect these have upon the medium in which they grow, some species evolving gases, others changing the chemical reaction of the medium. Variations also occur depending on the temperature at which the organisms are incubated, the presence or absence of oxygen, and other like conditions

Lastly, by inoculation in animals of different species and in different tissues, information valuable for the purpose of diagnosis may be obtained.

Pyogenic Bacteria.

From the point of view of the practical surgeon the most important varieties of micro-organisms are those which cause inflammation and suppuration—the *pyogenic bacteria.* This group includes a great many species, and these are so widely distributed that they are to be met with under all conditions of everyday life.

The nature of the inflammatory and suppurative processes will be considered in detail later; suffice it here to say that they are brought about by the action of one or other of the organisms which we have now to consider.

It is found that the *staphylococci* which cluster into groups tend to produce localised lesions; while the chain-forms—*streptococci*—give rise to diffuse, spreading conditions. Many varieties of pyogenic bacteria have now been differentiated, the best known being the staphylococcus aureus, the streptococcus, and the bacillus coli communis.

Staphylococcus Aureus.—This is the commonest organism found in localised inflammatory and suppurative conditions. It varies greatly in its virulence, being found in such widely different conditions as skin pustules, boils, carbuncles, and some acute inflammations of bone. It occurs in grape-like clusters as fission of the individual cells takes place irregularly. It grows very readily at the body temperature in artificial media, such as gelatin, which it liquefies, the organisms forming an orange yellow deposit at the bottom of the tube—hence the term *aureus.* It is of high vitality and resists more prolonged exposure to high temperatures than most non-sporing bacteria. It is widely distributed, and occurs in all situations where dust is present. It is found on the skin, in the mouth, and in other situations.

The other pyogenic staphylococci are of less importance. The *staphylococcus albus* is much less common than the aureus, but has the same properties and characters, save that its growth on artificial media assumes a white colour. It is the common cause of stitch abscesses, the skin being its normal habitat.

Streptococcus Pyogenes.—This organism, although it gives rise to more dangerous conditions than the staphylococcus, has less resisting power and therefore dies off more rapidly. Its peptonising power is also less, so that pus formation takes place more slowly. At the same time its products are very potent in destroying tissue in their vicinity, and so interfere with the exudation of leucocytes which would otherwise exercise their protective influence. Streptococci invade the lymph spaces, and are associated with acute spreading conditions such as phlegmonous or erysipelatous inflammations and suppurations, lymphangitis and suppuration in lymphatic glands, puerperal peritonitis and inflammation of other serous membranes, and inflammations of synovial membranes ; also with a form of septic pneumonia which is prone to follow on severe operations in the mouth. Streptococci are also concerned in the production of spreading gangrene and pyæmia. Division takes place in one axis so that chains of varying length are formed. It is less easily cultivated in artificial media than the staphylococcus ; it forms a whitish growth and does not liquefy gelatin.

Bacillus Coli Communis.—This organism, which is a normal inhabitant of the intestinal tract, shows a great tendency to invade any organ or tissue whose vitality is lowered. It is causally associated with such conditions as peritonitis and peritoneal suppuration resulting from strangulated hernia, appendicitis or perforation in any part of the alimentary canal. In cystitis, pyelitis, abscess of the kidney, suppurations in the bile ducts or liver, and in many other abdominal conditions it plays a most important part. The discharge from wounds infected by this organism has usually a very fœtid, or even a fæcal odour, and often contains gases of putrefaction.

It is a small rod-shaped organism with short flagella, which render it motile. It closely resembles the typhoid bacillus, but is distinguished from it by its behaviour in artificial culture media.

Pneumo-bacteria.—Two forms of organism are associated with pneumonia—*Fraenkel's pneumococcus* (one of the diplococci) and *Friedländer's pneumo-bacillus* (a short rod-shaped form). One or other of these may be met with in empyema, pericarditis, meningitis, otitis media, hepatic abscess, lymphadenitis, and various other inflammatory and suppurative conditions. They are most frequently found in company with the ordinary pyogenic bacteria, especially streptococci.

Bacillus Typhosus.—There is reason to believe that the typhoid bacillus possesses pyogenic properties, as it has been the only organism discovered in certain cases of acute suppurative periostitis, abscess of the kidney, parotid abscess, and in skin abscesses.

Other Pyogenic Bacteria.—It is not necessary to do more than name some of the other organisms which are known to be pyogenic, such as the bacillus pyocyaneus, which is found in green and blue pus; the micrococcus tetragenus; the gonococcus: actinomyces; glanders bacillus, and the tubercle bacillus. Most of these will receive further mention in connection with the diseases to which they give rise.

Leucocytosis.—Recent investigations have shown that most bacterial diseases, as well as certain other pathological conditions, are associated with an increase in the number of leucocytes per cubic millimetre in the blood of the peripheral vessels. This condition of the blood is known as *leucocytosis,* and is met with in nearly all the acute infective diseases, such, for example, as erysipelas, diphtheria, pneumonia, and scarlet fever. It is also present in acute pyogenic inflammatory affections, particularly in those attended with suppuration—for example, peritonitis, appendicitis, abscesses in joints and in internal organs. In gangrenous processes also, and in general septic poisonings, such as septicæmia and pyæmia, leucocytosis is present. In the final stages of malignant disease, and after a severe hæmorrhage, the number of leucocytes is usually markedly increased.

In these various affections it is chiefly the finely granular (neutrophile) polymorpho-nuclear leucocytes which are in excess (*ordinary leucocytosis*); although in some cases the eosinophile leucocytes also show a proportionate increase (*eosinophilia*). The term *lymphocytosis* is applied when there is an increase in the number of circulating lymphocytes.

The *normal* number of leucocytes per cubic millimetre varies in different individuals, and in the same individual under different conditions, from 5000 to 10,000. It is generally accepted that 7500 is a normal average, and that anything above 12,000 is to be considered as abnormal. When leucocytosis is present the number may range from 12,000 to 30,000 or even higher; 40,000 is looked upon as a high degree of leucocytosis.

The degree of leucocytosis is, as a rule, proportionate to the severity of the inflammatory affection and to the extent of the local lesion. It is to be borne in mind, however, that in very acute septic conditions the virulence of the toxins may prevent the leucocytes reacting, and leucocytosis may be absent. The absence of leucocytosis in a disease in which it is usually present is therefore to be looked upon as a grave omen, particularly when the general symptoms are severe.

The leucocytosis begins soon after the infection manifests itself—for example, by shivering, rigor, or rise of temperature. The number of leucocytes rises somewhat rapidly, increases while the condition is progressing, and remains high during the febrile period, but there is no constant correspondence between the number of leucocytes and the height of the temperature. The arrest of the inflammation and its resolution are accompanied by a fall in the number of leucocytes, while the occurrence of suppuration is attended with a further increase in their number.

In interpreting the "blood count" it is to be kept in mind that a *physiological leucocytosis* occurs within three or four hours of taking a meal, especially one rich in proteids, from 1500 to 2000 being added to the normal number (*digestion leucocytosis*). During the later months of pregnancy, and during the puerperium also, the leucocytes usually number from 16,000 to 18,000. In young infants, also, the leucocyte count is abnormally high.

Absence of Leucocytosis—Leucopenia.—In certain infective diseases the number of leucocytes in the circulating blood is abnormally low—3000 or 4000—and this condition is known as *leucopenia.* It occurs in typhoid fever, especially in the later stages of the disease ; in tuberculous lesions—for example, tuberculous peritonitis, pleurisy, ostitis, or periostitis, when unaccompanied by suppuration ; in malaria, and in most cases of uncomplicated influenza. The occurrence of leucocytosis in any of these conditions is to be looked upon as an indication that a mixed infection has taken place and that some suppurative process is in progress.

The absence of leucocytosis in some cases of virulent septic poisoning has already been referred to.

THE TEMPERATURE IN SURGICAL DISEASES.

It may be convenient here to study some of the variations in temperature met with in different forms of surgical disease.

A marked raising of the general temperature of the body is one of the most constant and important concomitants of all inflammatory affections, and the temperature chart forms a fairly reliable index of the severity of the patient's condition. It is due to the absorption into the circulation of bacterial products which interfere with the special nerve-centres in the medulla which regulate the balance between the production and the loss of body heat.

Clinically the temperature is estimated by means of a self-registering thermometer placed, for from five to ten minutes, in close contact with the skin in the axilla, or the temperature may be taken in the mouth. Sometimes the thermometer is inserted into the rectum, where, however, the temperature is normally ¾° F. higher than in the axilla.

In health the temperature of the body is maintained at a mean of about 98·4° F. (37° C.) by the heat-regulating mechanism. The temperature varies from hour to hour even in health. It reaches its maximum between four and eight in the evening, when it may rise to 99° F., and is at its lowest between four and six in the morning, when it may be about 97° F.

On reading and interpreting a temperature chart in disease, therefore, it is necessary to make allowance for this normal variation, and it is interesting to observe in this connection that an hourly chart of a case of acute septic infection runs parallel with the normal curve.

It is also worthy of note that the temperature is much more easily disturbed in children than in adults, and may become markedly elevated (104° or 105° F.) from comparatively slight causes ; while in the aged it is less liable to change, so that in them a rise to 103° or 104° F. is to be looked upon as indicating a high state of fever.

It is rare for a patient to live if the temperature remains for any length of time above 106° F., although some extraordinary cases are on record in which it has reached as high as 116° F. without proving fatal.

A sudden rise of temperature is usually associated with a feeling of chilliness down the back and in the limbs, which may be so marked that the patient shivers violently, while the skin becomes cold, pale, and shrivelled—*cutis anserina.* This is a nervous reaction due to a want of correspondence between the internal and the surface temperature of the body, and is known clinically as a *rigor*. When the temperature rises gradually the chill is usually very slight and may be unobserved. Even during the cold stage, however, the internal temperature is already raised, and by the time the chill has passed off its maximum has been reached.

These disturbances seem to follow the absorption of toxins into the blood, and to be due to an interference with the central heat-regulating mechanism.

The subsequent course of the temperature chart depends on the nature and amount of the poison absorbed ; whether it is the pure toxin of a single species of organism, or the result of a mixed infection by more than one species ; and whether the supply is intermittent or continuous.

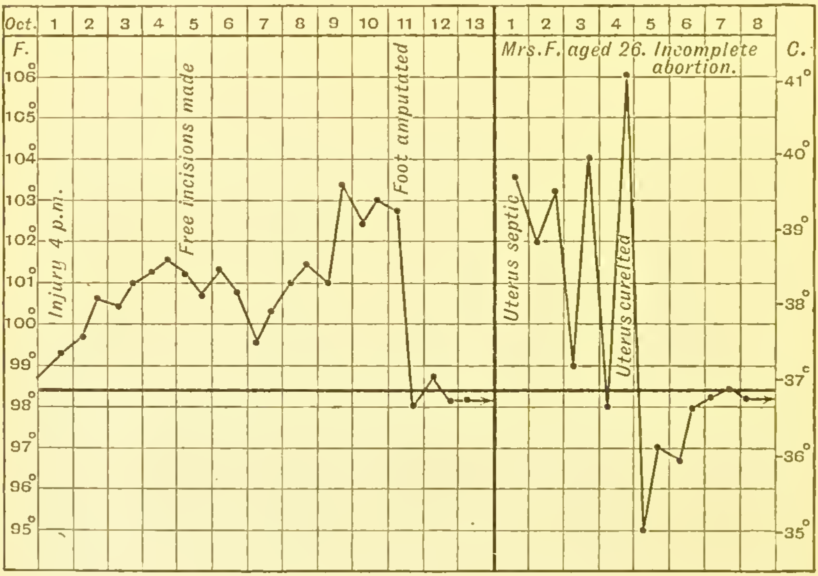

FIG. 1.—Charts of Acute Sapræmia from (*a*) case of crushed foot, and (*b*) case of incomplete abortion.

It follows, therefore, that certain groups of surgical conditions present particular types of temperature curve resembling one another more or less closely.

In *acute sapræmia* (p. 61), for instance, where the patient absorbs from a localised focus of infection a definite quantity of toxin either in a single large dose or in repeated small doses, the temperature rises rapidly, remains up till the poison is excreted, or till the source of its production is removed—for example, by amputation—or by the establishment of drainage, after which it falls again and remains normal.

The temperature may fall very rapidly and become markedly subnormal.

In the condition known as *hectic* (p. 62), which is a form of *chronic* sapræmia, the temperature chart is characterised by diurnal variations, ranging from 97° F. in the morning to 102° or 103° F. in the evening.

The rise usually begins in the afternoon, and the fall takes place suddenly in the early morning, and is accompanied by profuse sweating.

The same type of temperature curve is met with in cases of *surgical tuberculosis*, where there is, in all probability, a mixed infection.

In such conditions as *erysipelas* (p. 108), where a constant supply of toxin is poured into the system, the temperature remains elevated so long as the disease progresses, but falls more or less rapidly whenever its progress is arrested. A relapse is at once indicated by a second rise of temperature.

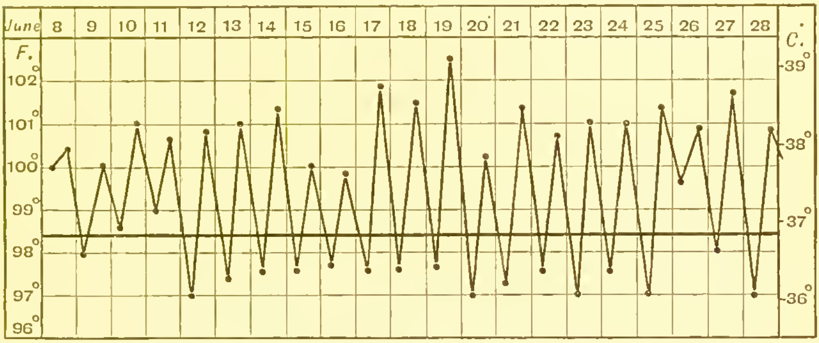

FIG. 2.—Chart of Hectic Fever.

In *septicæmia* (p. 63), organisms as well as toxins enter the circulation, and the temperature charts of this disease vary so widely that it is difficult to determine a type. So long as the diseases progresses, the temperature curve is practically the same as that of sapræmia or of erysipelas; but after it is arrested, the defervescence is more gradual, the temperature taking several days to reach the normal.

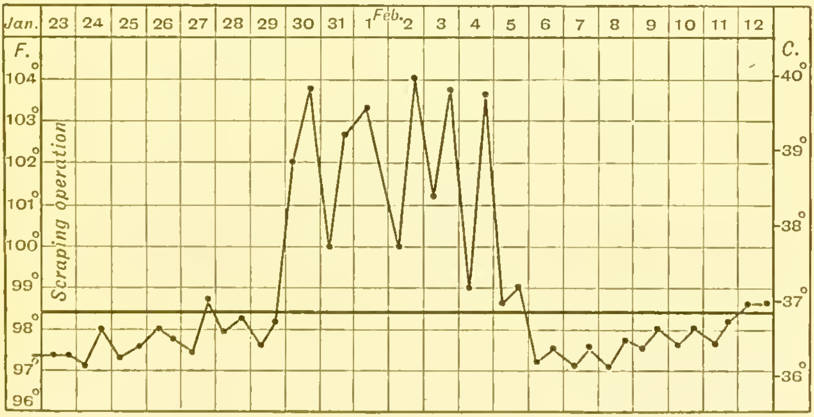

FIG. 3.—Chart of Erysipelas occurring in a wound.

In *pyæmia* (p. 65) secondary abscesses develop in different parts of the body from time to time, forming new foci of toxin production. Each fresh absorption of poison causes an elevation of temperature, which is usually accompanied by a rigor.

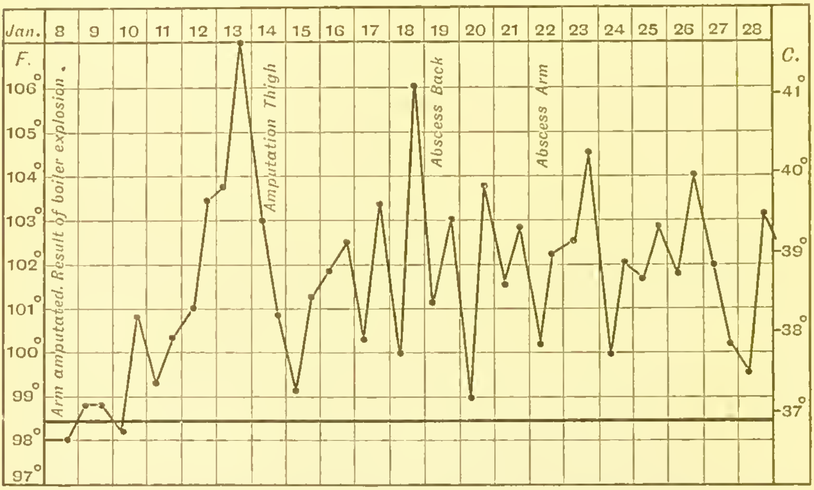

Fig. 4.—Chart of Pyæmia.

It is not uncommon for an attack of septicæmia to be followed by pyæmia, and then the type of chart changes (Fig. 6).

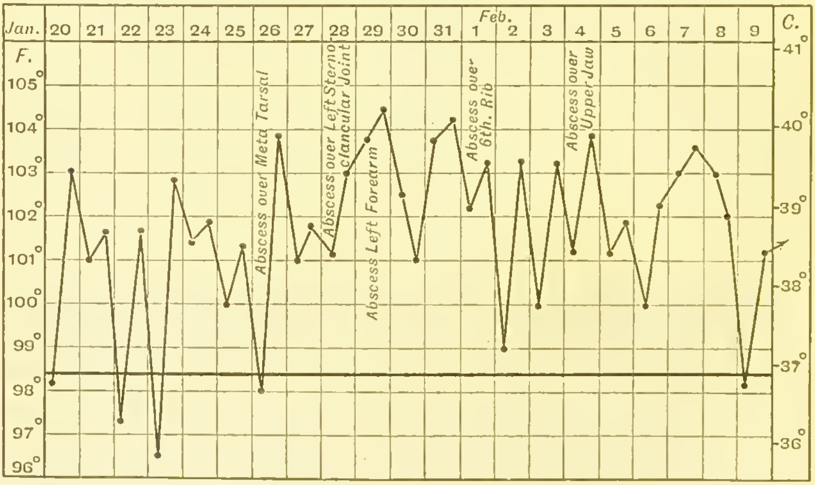

Fig. 5.—Chart of Pyæmia following on Acute Osteo-myelitis.

There are certain toxins which give rise to chart curves of a definite and distinctive character. The malarial poison, for example, produces a characteristic alteration of temperature, and patients who have once suffered from this disease are liable to marked rises from comparatively trivial causes. After minor operations or slight injuries, for instance, a sudden and marked rise may occur and cause needless apprehension of septic or other complications. The characteristic curves of other diseases also may be modified by the malarial poison.

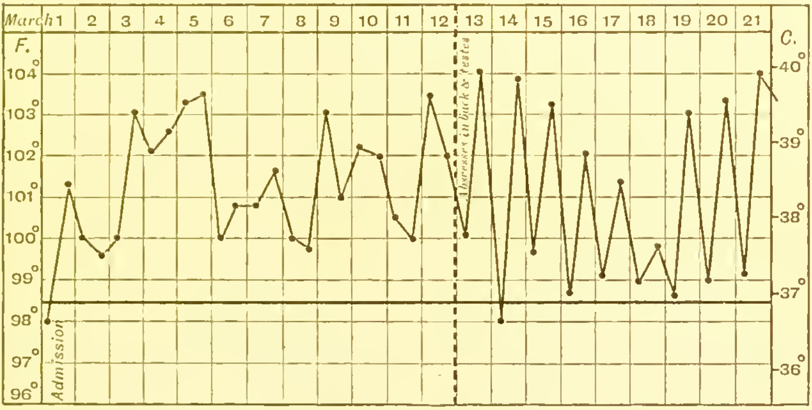

FIG. 6.—Chart of case of Septicæmia followed by Pyæmia.

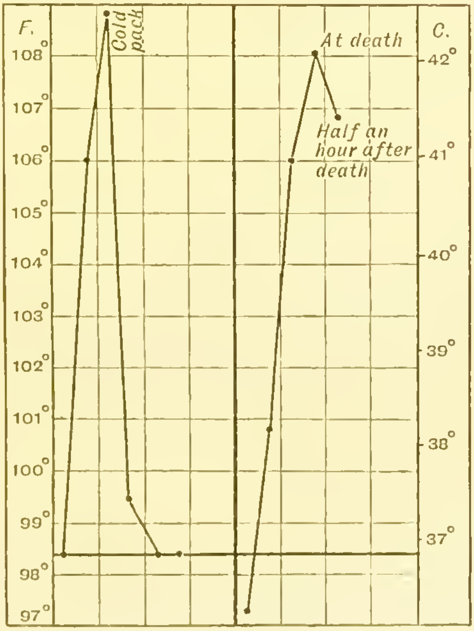

FIG. 7. Charts of Head Injuries.

After injuries or operations on the brain or upper part of the spinal cord sudden and excessive elevation of temperature, unaccompanied by rigors or vascular disturbances of the skin, is not uncommon as a result of direct damage to the central heat-regulating mechanism (Fig. 7).

It is almost needless to add that an elevation of temperature in a surgical patient is not always due to his surgical condition. Constipation, influenza, tonsillitis, injurious pressure by splints, the development of a bed sore, and many other complications may furnish an explanation.

Aseptic Fever.—An elevation of temperature, which is unassociated with the presence of inflammation or its causal bacteria, is frequently observed after surgical operations which have been attended with considerable shock and loss of blood, as well as after injuries attended with extravasation of blood into the tissues—for example, fractures. After a slight initial fall the temperature begins to rise, and in the course of from twelve to sixteen hours reaches 100° or 101° F. It soon declines again, and in from twenty-four to thirty-six hours has regained the normal. This rise is not associated with any of the other signs or symptoms of inflammation, and has been called *aseptic fever*, being attributed to the absorption into the circulation of certain of the products of disorganised blood or other disintegrated tissue.

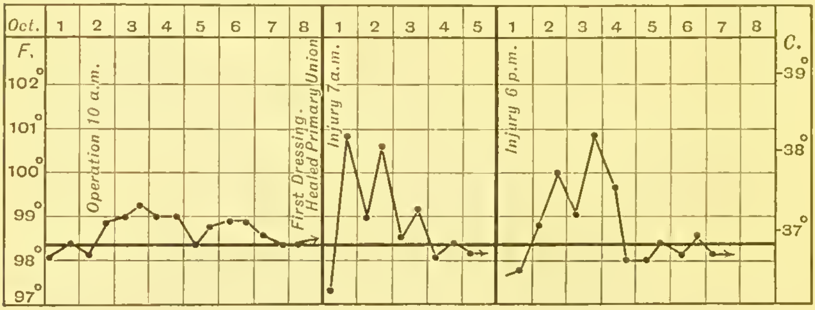

FIG. 8.—Charts of Aseptic Fever.

Subnormal Temperature (*Algidity*).—The general temperature of the body may fall below the normal from various causes. In severe railway or machinery accidents, for example, or in perforating wounds or diseases of the abdominal viscera, or, again, during the passage of biliary or urinary calculi, profound and dangerous lowering of the temperature may occur. The same result may follow a sudden and copious loss of blood, profuse diarrhœa, or severe vomiting; and it is a characteristic symptom in patients who are slowly starved, as, for example, in cases of stricture of the œsophagus. In most of these conditions, however, if death does not rapidly ensue, the temperature begins to rise and becomes elevated.

In some cases of extreme sapræmia or septicæmia also the temperature falls instead of rising, and this indicates a very grave prognosis. In cases of cerebral abscess and in some other conditions causing pressure on the brain the temperature remains persistently subnormal.

CHAPTER III.

METHODS OF WOUND TREATMENT.

Varieties of wounds—Modes of infection—Lister's work—Means taken to prevent infection of wounds: *heat; chemical antiseptics; disinfection of hands; instruments; ligatures; dressings*—Means taken to combat septic infection: *purification; open-wound method.*

The presence of pyogenic bacteria being the most important factor interfering with the process of repair in wounds, it is necessary that we should now consider the means at our disposal for preventing or counteracting the baneful effects of these organisms.

The surgeon is called upon to treat two distinct classes of wounds: (1) those resulting from injury or disease in which *the skin is already broken*, or in which a communication with a mucous surface exists; and (2) those which he himself makes *through intact skin*, no infected mucous surface being involved.

Infection by bacteria must be assumed to have taken place in all wounds made in any other way than by the knife of the surgeon operating through unbroken skin. On this assumption the modern antiseptic system of wound treatment is based. Pathogenic bacteria are so widely distributed that in the ordinary circumstances of everyday life, no matter how trivial a wound may be, or how short a time it may remain exposed, the access of organisms to it is almost certain, unless definite means are employed to prevent it.

It cannot be emphasised too strongly that rigid antiseptic precautions are to be adopted, not only in dealing with wounds which are free of organisms, but equally in the management of wounds and other lesions which are already infected. Any laxity in our methods which admits of fresh organisms reaching an infected wound adds materially to the severity of the septic process and consequently to the patient's risk.

There are many ways in which accidental infection may occur. Take for example the case of a person who receives a cut on the face by being knocked down in a carriage accident on the street. Organisms may be introduced to such a wound from the shaft or wheel by which he was struck, from the ground on which he lay, from any portion of his clothing which may have come in contact with the wound, or from his own skin. Or again, the hands of those who render first aid, the water used to bathe the wound, the handkerchief or other extemporised dressing applied to it, may be the means of conveying septic infection. Should the wound open on a mucous surface, such as the mouth or nasal cavity, the organisms constantly present in such situations are liable to prove agents of infection. The risk of direct infection from the air is much less than was at one time supposed.

Even after the patient has come under professional care the risks of his wound becoming infected are not past, because the hands of the surgeon, his instruments, dressings or other appliances may all, unless carefully purified, become the sources of infection.

In the case of an operation carried out through unbroken skin, organisms may be introduced into the wound from the patient's own skin, from the hands of the surgeon or his assistants, through the medium of contaminated instruments, swabs, ligature or suture materials, or other things used in the course of the operation, or from the dressings applied to the wound.

Further, bacteria may gain access to devitalised tissues by way of the blood-stream, being carried hither from some infected area elsewhere in the body.

The sources of wound infection being so numerous, it is little wonder that in former days few wounds of the class now under consideration escaped the ravages of pyogenic or other bacteria, and that inflammation, suppuration, erysipelas, hospital gangrene, and pyæmia were of everyday occurrence in surgical practice.

Those who only know the surgical conditions of to-day find it hard to believe that little more than thirty years ago, in a leading article in the *Lancet*, the writer stated that at that time "the mortality from compound fractures, amputations, and other operations such as lithotomy is something frightful"; that "death from blood poisoning is not confined to cases of serious operations, but happens ever and anon after operations in themselves trivial. It is lamentable," says the writer, "to think of the extent to which the best and most refined surgery of the time is being frustrated, in our great hospitals, and even in those most recently built. The risk of blood poisoning is now the one opprobrium of surgery."

To the genius of Lord Lister we owe it that this opprobrium is now removed. In 1867 he began to put into practice the method he had devised for preventing and counteracting the septic process, which he had convinced himself depended upon the action of bacteria. Carbolic acid was the first antiseptic agent he employed, and by its use in compound fractures he soon obtained results such as had never before been attained. The principle was applied to other conditions with like success, and so profoundly has it affected the whole aspect of surgical pathology that many of the septic diseases with which the older surgeons had to deal are now all but unknown.

Means taken to prevent Infection of Wounds.—The avenues by which septic agents may gain access to surgical wounds are so numerous and so wide, that it requires the greatest care and the most watchful attention on the part of the surgeon to guard them all. It is only by constant practice and patient attention to technical details, in the operating-room and at the bedside, that the carrying out of surgical manipulations in such a way as to avoid bacterial infection will become an instinctive act and a second nature. It is only possible here to indicate the chief directions in which danger lies, and to describe the means most generally adopted to meet the danger.

To prevent septic infection it is essential that everything which comes into contact with a wound should be thoroughly sterilised or disinfected. The two chief agencies at our disposal for this purpose are heat and chemical antiseptics.

Sterilisation by Heat.—The most reliable, and at the same time the most convenient and generally applicable means of sterilisation is by heat. All bacteria and spores are completely destroyed by being subjected for fifteen minutes to *compressed circulating steam* at a temperature of 130° to 145° C. (=266° to 293° F.). The articles to be sterilised are enclosed in a perforated tin casket, which is placed in a specially constructed steriliser, such as that of Schimmelbusch. This apparatus is so arranged that the steam circulates under a pressure of from two to three atmospheres, and permeates everything contained in it. Objects so sterilised remain dry. This method is specially suitable for appliances which are not damaged by steam, such, for example, as gauze swabs, towels, aprons, cotton gloves, and metal instruments.

The best substitute for circulating steam is *boiling*. The articles are placed in a "fish-kettle steriliser" and boiled for fifteen minutes in a one per cent solution of washing-soda or of lysol.

To prevent contamination of objects which have been sterilised, they must be conveyed directly from the steriliser to the wound, on no account being exposed to the dust of the air, or touched by any one whose hands have not been disinfected or protected by sterilised gloves.

Sterilisation by Chemical Agents.—For the purification of the skin of the patient, the hands of the surgeon, knives and other instruments which are damaged by heat, recourse must be had to chemical disinfecting agents. These, however, are less reliable than heat, and are open to certain other objections which will be referred to later.

In selecting from the enormous number of chemical antiseptic agents at our disposal that which is most suitable for a given case, consideration must be had to the following points:—(1) The object in view—whether to prevent septic infection or to eradicate it, and if the latter, the degree of virulence of the existing process; (2) the irritant action, toxicity, and absorbability of the drug; (3) the susceptibility to irritation and absorptive power of the surface to which it is to be applied; and (4) the action of the substance upon surgical instruments.

Carbolic Acid.—This agent is of much historical interest, being that employed by Lord Lister when he first introduced the antiseptic system in 1867. In a field of a hundred competitors it still remains one of our most reliable antiseptics. The lotion is made by dissolving the crystals of the pure acid in water in the proportion of 1 in 20, 1 in 40, or 1 in 60. It is a reliable germicide, has a marked power of penetrating the tissues, and has no deleterious action upon metal instruments. On the other hand, it is irritating to the tissues, and induces a considerable oozing of serum from raw surfaces. If absorbed, it acts as a general poison, the first sign of its toxic effects being discoloration of the urine, which is olive-green when passed, but changes to black on standing. If absorption goes on, giddiness, nausea, and vomiting are induced. The patient may become profoundly collapsed, with a small, rapid pulse and subnormal temperature, and may ultimately die. Such accidents have frequently occurred from absorption through unbroken skin where a compress of carbolic solution has been applied preparatory to operation, and are most to be feared in children and females with tender skin. The phenol products may be detected in the urine by adding to it a few drops of perchloride of iron solution, which gives a blue colour; or a small quantity of bromine water, which throws down a whitish precipitate of tribromophenol.

Pure carbolic acid (phenol), when applied to a raw surface, does not produce symptoms of poisoning, as it causes coagulation necrosis of the superficial layers of the tissue, and this prevents it being absorbed.

The application of wet compresses of carbolic lotion to the fingers and toes is to be avoided, especially in women and children, on account of the risk of inducing carbolic gangrene.

Corrosive Sublimate.—This lotion is made by dissolving the crystals of perchloride of mercury in distilled water. It is used in strengths varying from 1 in 500 to 1 in 5000; that usually employed being 1 in 2000. Although less irritant locally than carbolic lotion, it is more poisonous by absorption, causing abdominal pain, diarrhœa, vomiting, and collapse, which may prove fatal. It corrodes metal instruments and dishes; and by its action on the albumen of the tissues and of the blood forms an inert albuminate of mercury, so that its antiseptic efficiency is much diminished. Corrosive sublimate is probably the most efficient lotion for purifying the hands after being contaminated with septic material.

Lister's Strong Solution is prepared by making a 1 in 20 solution of carbolic acid in distilled water, in every 500 parts of which one part of perchloride of mercury is dissolved.

Biniodide of Mercury.—This lotion is widely used as a substitute for corrosive sublimate. It is a more powerful germicide, while it is less irritant, and it neither forms a mercuric albuminate nor tarnishes metallic instruments. This lotion is used in the same strengths as corrosive sublimate lotion, and may either be dissolved in water or in spirit.

Formalin, in one per cent. solution, is useful for purifying the skin before operation, and for washing out tuberculous sinuses and other infected cavities.

Peroxide of Hydrogen is of great value in disinfecting and deodorising septic wounds and cavities. It acts in virtue of its oxidising properties. Each volume of the fluid contains from ten to fifteen volumes of oxygen in such feeble combination that it is at once given up when it comes into contact with any oxidisable substance. It is most conveniently applied in the form of a spray.

Boracic Acid Lotion is a saturated solution of boracic acid crystals in water. It is a weak, non-poisonous lotion of some value as a preventive of sepsis, but of little germicidal power. It is useful in washing out the urinary bladder and as a mouth-wash.

Lysol, one of the newer proprietary antiseptics, is most useful in cleansing the skin of the patient and the surgeon's hands both before and after operations. It is used in strengths varying from 1 in 100 to 1 in 400. It combines the advantages of an antiseptic solution and a soap. Its irritating action on the skin of the hands may to a large extent be prevented by rinsing the hands in sterile water to get rid of the lysol. As it forms a ropy mixture when brought into contact with pus or blood it is not a suitable lotion for wounds.

Izal, *creolin*, and *sanitas* are useful disinfectant and deodorant lotions of the non-official class.

Iodoform is a feeble germicide, but possesses a peculiar property of neutralising the products of bacteria when it is broken up in contact with the tissues of the body. To this property—probably in virtue of the liberation of free iodine in the process of its disintegration—it owes its undoubted value in wounds with a foul discharge, in tuberculous conditions, and in venereal sores. It is also useful in wounds in the neighbourhood of septic cavities, such as the mouth or rectum, as a means of preventing or controlling sepsis. It is best employed in the form of moderate-sized crystals, which should be sterilised by immersion in 1 in 20 carbolic before being used, as micro-organisms are capable of living in the dried powder.

In children and in weakly old people symptoms of poisoning by absorption may occur, in the form of loss of appetite, dry tongue, raised temperature, and rapid pulse, and mental depression or excitement. These symptoms seem more prone to occur when the drug is used in tissues rich in fat, and especially when the fine powder is employed, this being more readily absorbed than the crystalline form. Iodoform may be detected in the urine of such cases by adding an equal quantity of concentrated hydrochloric acid, and pouring on the surface a little chloride of lime solution. At the junction of the fluids there forms a brown ring, which turns blue on the addition of some starch solution.

Some persons show a peculiar idiosyncrasy with regard to their local reaction to iodoform, an acute spreading erythematous or pustular rash, with intense itching, developing from the slightest contact with it. Marked constitutional symptoms may accompany these local manifestations. In some patients persistent vomiting is induced by the smell of the drug.

Disinfection of the Hands.—It is now generally recognised that one of the most fertile sources of wound-infection is the hands of the surgeon and his assistants. In the exigencies of surgical practice it is hardly possible for the surgeon consistently to avoid contaminating his hands with septic material, and once they are so contaminated it is extremely difficult again to render them germ-free. It is only by carefully studying to avoid all contact with infective matter that the hands can be kept surgically pure and that this source of wound-infection can be reduced to a minimum. To aid in this, india-rubber gloves should be worn while operating on septic cases, such as suppurative cellulitis, osteo-myelitis, suppurative appendicitis, or other conditions associated with pus formation, in making rectal or vaginal examinations, or in dressing suppurating wounds. It has been shown that if the hands be kept free of septic material for a sufficiently long period, they can for all practical purposes be rendered germ-free by ordinary methods of purification. It is of the utmost importance that any septic matter with which the hands may accidentally become defiled should not be allowed to dry on them, but should be washed off at once, and for this purpose 1 in 1000 corrosive sublimate appears to be the best lotion to employ.

Many methods of disinfecting the hands have been suggested by different surgeons; the most important step in all being the mechanical removal of gross surface dirt and loose epithelium by soap, a stream of running water, and a nail-brush. Various forms of soft soap, as well as soda, turpentine, lysol, and other substances are useful in removing grease and gross dirt from the skin. Pumice-stone soap is useful in rubbing off the loose epithelium. The nails should first be cut down till there is no sulcus between the nail edge and the pulp of the finger in which organisms may lodge. The hands are then thoroughly washed in hot running water and scrubbed with a nail-brush which has been previously sterilised by boiling, and kept in a 1-1000 solution of corrosive sublimate. They are next washed in 85 per cent alcohol, and the excess of alcohol removed by rinsing in sterilised water. Finally, they are rubbed with wet sterilised gauze. The whole process occupies about ten minutes.

On account of the difficulty of rendering the hands surgically pure, many surgeons recommend the wearing of cotton gloves, originally introduced by Mikulicz, while operating. It is necessary to change the gloves frequently during the course of a prolonged operation, because when they become moist with blood or other fluids they are permeable to the skin secretions, and organisms from the folds and ducts of the skin which have escaped the preparatory cleansing may pass through the meshes of the cotton and so reach the wound. By Kocher the gloves are chiefly used in ligaturing the blood-vessels and inserting sutures, with a view to preventing the catgut or silk being contaminated by coming into contact with the surgeon's hands.

Preparation of the Skin of the Patient.—In the purification of the skin of the patient before operation, reliance is chiefly to be placed in the mechanical removal of dirt and grease by the same means as are taken for the cleansing of the surgeon's hands. Hair-covered parts should be shaved. The skin is then dehydrated by washing with alcohol, and this is followed by 1 in 1000 sublimate or biniodide solution. For some hours before the operation the part is covered by a moist compress of 1 in 60 carbolic. In children a compress of 1 per cent formalin left on for twenty-four hours is safer than carbolic solution, which is apt to be absorbed. Immediately before the operation the skin is purified in the same way as the surgeon's hands. If any acne pustules or septic sinuses are present, they should be destroyed or purified by means of the thermo-cautery or pure carbolic acid, after the patient is anaesthetised.

Instruments which are not damaged by heat must be boiled in a fish-kettle or other suitable steriliser for fifteen minutes in soda solution or lysol. Just before the operation begins they are removed in the tray of the steriliser and placed on a sterilised towel within reach of the surgeon or his assistant. If a special assistant is employed to look after the instruments, he should protect his hands by gloves after having washed them thoroughly. Knives and instruments which are liable to be damaged by heat should be purified by being soaked in 1 in 20 carbolic for at least an hour. After operation the instruments should be boiled, dried, and kept in a dust-proof box or cupboard.

Pads of Gauze sterilised by compressed circulating steam have entirely superseded natural sponges for operative purposes. They should be removed from the caskets in which they are sterilised by means of sterilised forceps, and handed direct to the surgeon. The assistant who attends to the swabs should wear sterilised gloves.

Ligatures and Sutures.—To avoid the risk of implanting infective material in a wound by means of the materials used for ligatures and sutures, great care must be taken in their preparation.

Catgut.—The following methods of preparing catgut have proved satisfactory :—(1) The gut is soaked in juniper oil for at least a month ; the juniper oil is then removed by ether and alcohol ; and the gut preserved in 1 in 1000 solution of corrosive sublimate in alcohol (Kocher). (2) The gut is placed in a brass receiver and boiled for three-quarters of an hour in a solution consisting of 85 per cent absolute alcohol, 10 per cent water, and 5 per cent carbolic acid, and is then stored in 90 per cent alcohol. It should be removed from the stock bottle with aseptic forceps and passed direct to the surgeon. Any portion unused should not be returned to the stock bottle.

Silk.—If rendered thoroughly sterile, the smaller sizes of silk, Nos. 1 and 2, may safely be used for the ligature of blood-vessels. It is prepared by being soaked for twelve hours in ether, for other twelve in alcohol, and then boiled for ten minutes in 1 in 1000 sublimate solution. It is then wound on to spools with purified hands protected by sterilised gloves, and kept in absolute alcohol. Before an operation the silk is again boiled for ten minutes in the same solution, and is used directly from this (Kocher).

Horse - hair, fishing - gut, silver wire, and other suture materials, as well as the needles, should be boiled along with the instruments.

The Field of Operation is surrounded by macintoshes covered over with sterilised towels, securely fixed in position so that no contamination may take place from the surroundings.

The surgeon and his assistants, including the anæsthetist, should wear over-alls sterilised by steam.

The risk of infection from the *air* is now known to be very small, so long as there is no excess of dust floating in it. All sweeping, dusting, and disturbing of curtains, blinds, or furniture must therefore be avoided before or during an operation.

It has been shown experimentally that the presence of spectators increases the number of organisms in the atmosphere. In teaching clinics, therefore, the risk from air infection is greater than in private practice.

To facilitate primary union, all hæmorrhage should be carefully arrested, and the accumulation of fluids in the wound prevented. When much oozing of serum or blood is anticipated, a glass or rubber drainage-tube should be inserted through a small opening specially made for the purpose. In aseptic wounds the tube may be removed in from twenty-four to forty-eight hours; in infected wounds it must remain as long as the discharge lasts.

The edges of the wound should be brought into accurate apposition by sutures. If any cavity exists in the deeper part of the wound, it should be obliterated by buried sutures, or by so adjusting the dressing as to bring its walls into apposition.

If our precautions have been successful, the wound will heal under the original dressing, which need not be interfered with for from ten to fourteen days according to the nature of the case.

Dressings.—*Gauze*, either sterilised by heat, or impregnated with corrosive sublimate, double cyanide of mercury and zinc, iodoform, or other antiseptic agent, is now widely used in the treatment of wounds.

Pads of *sterilised gauze* are extensively used as a dressing for operation wounds. By some surgeons *double cyanide gauze* is preferred. *Iodoform gauze* is of special value for the packing of wounds treated by the open method.

One variety or another of *wool*, rendered absorbent by the extraction of its fat, forms a part of almost every surgical dressing; and various antiseptic agents may be added to it. Of these corrosive sublimate is the most generally used. Wood-wool dressings are more highly and more uniformly absorbent than cotton wools. As evaporation takes place through wool dressings, the discharge becomes dried, and so forms an unfavourable medium for bacterial growth.

Boracic Lint is prepared by soaking ordinary lint in a hot concentrated solution of boracic acid and then drying it. It is usually employed as a wet dressing or poultice, being wrung out of boracic lotion, applied to the part, and covered with gutta-percha tissue.

Means adopted to combat Septic Infection.—As has already been indicated, the same antiseptic precautions are to be taken in dealing with infected as with aseptic wounds.

In the case of *recent injuries* such as result from railway or machinery accidents, with bruising and crushing of the tissues, and grinding of gross dirt into the wounds, the scissors must be freely used to remove the devitalised structures and the foreign material. Hair-covered parts should be shaved. Crushed and contaminated portions of bone should be chiselled away. Opinions differ as to the benefit derived from washing such wounds with strong lotions, which are liable to devitalise the tissues with which they come in contact, and so render them less able to resist the action of any organisms which may remain in them. All are agreed, however, that free washing with normal salt solution is useful in mechanically cleansing the injured parts. Peroxide of hydrogen sprayed over such wounds is also beneficial in virtue of its oxidising properties. Efficient drainage must be provided, and stitches should be used sparingly, if at all.

The best way in which to treat such wounds is by the *open-wound method*. This consists in packing the wound with iodoform gauze, which is left in position as long as it adheres to the raw surface. The packing may be renewed at intervals until the wound is filled by granulations; or in the course of a few days, when it becomes evident that the septic infection has been overcome, *secondary* sutures may be introduced and the edges drawn together, provision being made at the ends for further packing or for drainage-tubes. These measures have been found specially useful in military surgery.

If earth or street dirt has entered the wound, before introducing the iodoform gauze, the surface may with advantage be brushed over with pure carbolic acid, as virulent organisms, such as those of tetanus or spreading gangrene, are liable to be present.

Where septic processes have become established in a wound, and suppuration is going on and probably spreading in the tissues, the first essential in treatment is to ensure free drainage by openings and counter-openings, if necessary. The open method is the only safe means of treating such wounds. The infected surface may be sponged over with pure carbolic acid, and the wound either drained by tubes or packed with iodoform gauze. The practice of scraping such surfaces with the sharp spoon, squeezing, or even of washing them out with antiseptic lotions, are attended with the risk of further diffusing the organisms in the tissue, and are only to be employed under exceptional circumstances. Continuous irrigation of septic wounds or their immersion in antiseptic baths is sometimes useful.

Wounds in the vicinity of the mouth or rectum are treated on the same principles as infected wounds—by the open method.

CHAPTER IV.

INFLAMMATION.

Nature of inflammation from surgical point of view—Sequence of changes in inflammation—Clinical aspects of inflammation—General principles of treatment—Results of inflammation—Chronic inflammation.

The infection of a wound by pathogenic bacteria is soon followed by a complex series of changes in the affected tissues which constitutes the process of inflammation. This process is to be looked upon as the reaction of the tissue elements to the irritation caused by the invading micro-organisms and their products. Certain tissue changes similar to, if not identical with, those of inflammation due to bacterial action, result from mechanical or thermal injury of a part, or the application of purely chemical substances to the tissues, and the early stages in the process of ideal repair are characterised by changes of a like kind. From the clinical point of view, however, these processes are to be looked upon as the physiological effects of *stimulation* of the tissues acting reflexly through the nervous system, rather than as the pathological results of *irritation*. The local structural changes and the general constitutional effects of these conditions differ so widely from those of true inflammation of bacterial origin, that to attempt to include all in one category seems calculated to obscure the essential characters of each and to lead to confusion. The true significance of inflammation in surgical pathology will only be appreciated when bacterial action is accepted as its only cause.

Inflammatory reaction appears to have for its primary object the arrest and expulsion of the attacking organisms, and to this extent may be looked upon as protective in its nature. Should the issue of the struggle between the tissues and the bacteria be favourable to the latter, the further phases of the inflammatory process are essentially of a destructive character. The idea that inflammation is a reparative process, as is held by some, cannot be entertained. Clinical experience and pathological facts prove the existence of inflammation in a wound to be incompatible with repair. Any healing which may take place in an inflamed wound goes on in spite of the inflammation and not as a result of it, and in most cases repair only begins when inflammation ceases. It has already been pointed out that the fundamental object of our modern methods of wound treatment is the prevention of inflammation, and that it is only when we succeed in attaining this object that we obtain that form of repair which we consider ideal. To admit that inflammation is essential to repair is to relinquish the antiseptic idea.

Sequence of Changes in Inflammation.—For purposes of study the process of inflammation may be divided into four phases or stages—hyperæmia, congestion, stasis, and thrombosis; but as these stages imperceptibly merge into one another, and as the inflammatory process may become arrested at any stage, it is to be understood that the subdivision is to a large extent arbitrary.

The characteristic tissue changes take place in and around the minute blood-vessels of the inflamed part, and are essentially the same whether the process arises in or apart from a traumatic lesion.

In the *normal capillary* the red corpuscles occupy the centre of the stream, while the leucocytes and the fluid elements of the blood tend towards the periphery of the vessel.

The first or *hyperæmic* stage of inflammation supervenes on the infection of a wound, and is characterised by an increased rapidity in the blood-flow, a dilatation of the capillaries implicated, and an increased exudation of serous fluid into the surrounding connective tissue. The amount of blood passing through the inflamed area is greatly increased, and on account of this increased quantity of blood, the short time it remains in the part, and the diminished metabolic activity of the tissues, it does not lose its oxygen, and so remains of a bright red colour. The clinical features of this stage, therefore, are redness and œdematous swelling. As the serous exudation from the dilated vessels does not coagulate, the part remains soft and pits on pressure.

In the stage of *congestion* the vessels still further dilate, but the rate of flow diminishes. The white corpuscles fall more and more out of the axial stream of the vessel, and accumulate against the capillary wall. In this stage the part becomes more swollen and of a darker hue.

As the vitality of the tissue continues to diminish, the activity of the bacteria increases, so that a greater quantity of toxins is produced, and further evidences of their action on the tissues become manifest. The accumulation of leucocytes in the peripheral parts of the vessels increases, the blood as it comes into contact with the devitalised portions of the vessel wall has its flow arrested,—*stasis*,—and the red corpuscles fall out of the central part of the vessel and mix with the serum and leucocytes. Leucocytes find their way through the walls of the small veins and capillaries in gradually increasing numbers, till the whole of the connective tissue in the vicinity becomes infiltrated with them—*emigration of leucocytes.* The fluid portion of the blood also exudes through the walls, and the connective tissue becomes water-logged. Red corpuscles are carried out through the openings made by the leucocytes, and lie singly or in clumps in the meshes of the connective tissue—*diapedesis of red corpuscles.*

The emigration of leucocytes, resulting in a local leucocytosis, is one of the most important phenomena of inflammation, and on it the protective character of the inflammatory process depends. Leber has shown that the leucocytes leave the vessels in obedience to a form of chemical or of biological attraction existing between them and the bacteria or their products. This is named *chemiotaxis.* The determination of leucocytes to the seat of bacterial invasion in this way enables them to bring their phagocytic action to bear against the organisms, and so to check their advance. Coincidently with these changes, a proliferation of the fixed tissue cells of the part takes place.

As has been said, the serous exudate in this stage of inflammation is copious, and it varies in character with different micro-organisms and in different tissues.

When the exudate remains fluid, it is spoken of as *serous*, as in serous synovitis. In most inflammations the exuded fluid coagulates more or less completely, being then termed *sero-fibrinous.* On the free surface of mucous membranes it sometimes forms a dull grey tough layer, composed of a mixture of fibrin, mucin, and dead epithelial cells, constituting a *croupous* exudate. In very vascular tissues with friable vessels, during an acute inflammation, somewhat copious bleeding may accompany the exudation into the tissues—*hæmorrhagic* exudate. Other terms, which explain themselves, are applied to inflammatory exudates, such as purulent, putrid, ichorous.

In severe and long-continued inflammation the endothelium of the vessels becomes so profoundly altered that *thrombosis*, or clotting of the blood in the vessels, takes place. In the thrombotic stage of inflammation the blood-flow is completely and permanently arrested, and the vitality of the tissue is seriously endangered.

Clinical Aspects of Inflammation.—It must clearly be understood that inflammation is not to be looked upon as a disease in itself, but rather as an evidence of some infective process going on in the tissues in which it occurs, and of an effort on the part of these tissues to overcome the invading organisms and their products. The chief danger to the patient lies, not in the reactive tissues which constitute the inflammatory process, but in the fact that he is liable to be poisoned by the toxins of the bacteria at work in the inflamed area.

Since the days of Celsus (first century, A.D.), heat, redness, swelling, and pain have been recognised as cardinal signs of inflammation, and to these may be added, interference with function in the inflamed part, and general constitutional disturbance.

Inflammation may exist in a part and yet some of these signs be absent, or certain of them may be present although the tissues are not inflamed, but the coexistence of all, or even of a majority of them, is, in most instances, sufficient to establish the diagnosis of inflammation. Variations in the intensity of these signs and symptoms depend upon the acuteness of the condition, the nature of the causal organism and of the tissue attacked, the situation of the part in relation to the surface, and other factors.

The *heat* of the inflamed part is to be attributed to the increased quantity of blood present in it, the actual temperature of the blood at the seat of inflammation being no higher than in other parts of the body. The more superficial the inflamed part the more readily is the local increase of temperature detected by the hand. This clinical point is best tested by placing the palm of the hand and fingers for a few seconds alternately over an uninflamed and an inflamed area, otherwise under similar conditions as to coverings and exposure. In this way slight differences may be recognised.

Redness, similarly, is due to the increased afflux of blood to the inflamed part. The shade of colour varies with the stage of the inflammation, being lighter and brighter in the early, hyperæmic stages, and darker and duskier when congestion and stasis have occurred and the oxygenation of the blood is defective. In the thrombotic stage the part may assume a purplish hue.

When a deep part, such as periosteum or bone, is the seat of inflammation, surface redness may be slight or even absent.

The *swelling* is due to the increased quantity of material in the affected part—circulating blood, effused serum and leucocytes, and proliferated tissue cells. The more open the structure of the tissue of the part, the greater is the amount of swelling, witness the marked degree of swelling in the scrotum or in the eyelids produced by even a slight inflammation. In deep-seated inflammations of rigid tissues or encapsuled organs, however, there is often a marked œdematous swelling of the overlying soft parts, due to direct or reflex interference with the circulation of the part.

Pain is a symptom seldom absent in inflammation. *Tenderness*—that is pain elicited on pressure—is one of the most valuable diagnostic signs we possess, and is often present before pain is experienced by the patient. That the area of tenderness corresponds to the area of inflammation is almost an axiom of surgery. Pain and tenderness are due to the local irritation of nerve filaments, rendered all the more sensitive by the abnormal conditions of their blood-supply.

Much value attaches to the character of the pain as described by the patient. Thus inflammations of the skin cause pain of a *burning* or *itching* character; the pain of inflammation in dense tissues like periosteum or bone, or in encapsuled organs, is described as *dull*, *boring*, or *aching*. When inflammation is passing on to suppuration the pain assumes a *throbbing* character, and as the pus reaches the surface, or "points," as it is called, sharp, *darting*, or *lancinating* pains are experienced. Inflammation involving a nerve-trunk may cause a *boring* or a *tingling* pain; while the implication of a serous membrane such as the pleura or peritoneum gives rise to pain of a sharp *stabbing* character.

Pain may be *referred* to parts at a distance from the actual seat of the inflammation; for example, pain in the knee is a common symptom of disease in the hip joint.

Interference with the function of the inflamed part is always present, varying in degree with the severity of the inflammation and its seat. An inflamed joint, for example, may have its range of movement diminished or may be absolutely fixed: an inflamed eye may be hypersensitive to light or may be rendered blind.

Constitutional Disturbances.—Under the term constitutional disturbances are included the presence of fever or elevation of temperature; certain changes in the pulse rate and the respiration; gastro-intestinal and urinary disturbances; and derangements of the central nervous system. These are all due to the absorption of toxins into the general circulation.

Fever.—The nature and significance of alterations in the temperature in inflammatory and other pathological conditions have already been referred to.

The *pulse* is always increased in frequency during inflammation and usually varies directly with the height of the temperature. In the early stages, while the temperature is rising, it may be small and firm; during the height of the inflammation it is full and bounding; and if the process be long continued it tends to become small, soft, and weak, or even dicrotic and irregular.

Respiration is more active during the progress of an inflammation. Bronchial catarrh is common, apart from any antecedent local respiratory disease.

Gastro-intestinal disturbances are usually present in the form of loss of appetite, diminished secretion of the alimentary juices, and weakening of the peristalsis of the bowel, leading to constipation, great thirst, and dry, furred tongue. Diarrhœa is sometimes present.

The *urine* is usually scanty, of high specific gravity, rich in nitrogenous substances, especially urea and uric acid, and in calcium salts, while sodium chloride is deficient. Albumen and hyaline casts may be present in cases of severe inflammation with high temperature.

Leucocytosis is generally present in acute inflammations of moderate severity.

Clinical Features of Inflammation complicating a Surgical Wound.—If in the course of a surgical operation bacterial infection of the wound has occurred, inflammatory reaction soon manifests itself. In from twenty-four to forty-eight hours after the operation the patient is conscious of a sensation of chilliness, or may even have a distinct rigor. At the same time he feels generally out of sorts, with impaired appetite, headache, and it may be looseness of the bowels. His temperature rises to 100° or 101° F., and the pulse quickens to 100 or 110.

On exposing the wound it is found that the parts for some distance around are red, glazed, and œdematous. The discoloration and swelling are most intense in the immediate vicinity of the wound, the edges of which are everted and moist. Any stitches which may have been introduced are tight, and the deep ones may be cutting into the tissues. There is heat, and a constant burning or throbbing pain, which is increased by pressure. On inserting a probe between the lips of the wound a quantity of dark serous or sanious fluid escapes, or the discharge may even already have become purulent.

General Principles of Treatment in Inflammatory Conditions and in Inflamed Wounds.—The main object of treatment in these conditions is to help the tissues in the contest with the bacteria and their toxins. This is done in two ways—(1) by attacking the organisms and so removing the cause of the inflammation; and (2) by improving the condition of the tissues so as to increase their power of defending themselves.

The bacteria may be attacked directly by means of strong antiseptic agents locally applied.

In such conditions, for example, as acute lymphangitis, or diffuse inflammation of the subcutaneous tissue, where the skin is unbroken, carbolic acid, in virtue of its penetrating power, if applied on fomentations in the strength of 1 to 40, will act directly on the organisms, and so allay the inflammation.

On open surfaces, and in acne spots, boils, or similar conditions, the undiluted acid may be locally applied with the same object.

By establishing free drainage, so that no fluid discharges are allowed to remain in the tissues, and by keeping the surface dry, the organisms may be starved out.

Various drugs administered internally, such as quinine, salol, sulpho-carbolate of soda, and others, have a reputation, more or less deserved, as internal antiseptics.

The toxins may be neutralised locally by such applications as iodoform or its substitutes; or their elimination may be hastened by stimulating the emunctories. A saline purge, such as half an ounce of sulphate of magnesium in a small quantity of water, ensures a free evacuation of the bowels. The kidneys are flushed by such diluent drinks as equal parts of milk and lime water, or milk with a dram of liquor calcis saccharatus added to each tumblerful. Barley-water, and "Imperial drink," which consists of a dram and a half of cream of tartar added to a pint of boiling water and sweetened with sugar after cooling, are also useful and non-irritating diuretics.

The skin may be stimulated by Dover's powder (10 grains), or liquor ammoniæ acetatis in three dram doses every four hours.

The general health of the patient must be kept up by regularly-administered diets of fluid food, such as milk, beef-tea, meat juices or gruel, rendered more easily assimilable by artificial digestion if necessary. Stimulants and tonics will be given if indicated.

The tissues of the inflamed part are greatly aided in their struggle with the bacteria by a plentiful supply of healthy blood passing through them. To this end the part must be placed in such a position that no mechanical obstruction is offered to the circulation. An inflamed limb must be elevated to favour the venous return, and all bandages, splints, or other appliances must be so designed as to favour, and not to retard, the blood-flow.

Blood-letting.—In some cases more active aid must be given to the circulation by the relief of congestion by blood-letting, which may be general or local. *General blood-letting* consists in opening a superficial vein (venesection) and allowing from eight to ten ounces of blood to flow from it. The median basilic vein is usually selected for this purpose. A ligature is tied round the upper arm to distend the vessel, which is then opened by an oblique incision through the skin. After the desired amount of blood has been withdrawn, the ligature is removed, the elbow flexed, a pad of antiseptic gauze firmly bandaged over the incision, and the arm is carried in a sling for a few days.

Local blood-letting is a commoner surgical practice than venesection, and may be effected by leeches, cupping, or incision.

Before applying *leeches* the part must be thoroughly cleansed, and if the leech is slow to bite, may be smeared with cream. The leech is retained in position under an inverted wine-glass or wide test-tube till it takes hold. After it has sucked its fill it usually drops off, having withdrawn about a dram or a dram and a half of blood. If it be desirable to withdraw more blood, hot fomentations should be immediately applied to the bite. As it is sometimes necessary to employ considerable pressure to stop bleeding from a leech bite, leeches should, if possible, be applied over a bone which will furnish the necessary resistance. The use of styptics may be called for.

Cupping.—Two methods of cupping are employed—dry and wet. In *dry cupping* a small tumbler, the inside edge of which has previously been oiled, has a piece of blotting-paper soaked in methylated spirit placed in it and ignited. While still burning the tumbler is inverted and pressed firmly over the part to be cupped. The burning of the air and the subsequent cooling create a partial vacuum inside the glass, and the skin and subcutaneous tissue full of blood and fluid are drawn into it. To release the glass the finger-nail is gently inserted under its edge.

In *wet cupping* the skin is scarified by a lancet before the cup is applied. Each cup withdraws about two or three drams of blood, and if more is desired, hot fomentations may be applied.

Free incisions, with antiseptic precautions, are safe and certain as a means of letting blood, and may be called for in deep-seated inflammations to relieve extreme tension.

Cold.—Cold is only to be employed in the early hyperæmic stages of inflammation. It acts by contracting the blood-vessels and so diminishing the amount of blood reaching the part. In the stages of congestion or stasis its use is attended with considerable risk, as it diminishes the blood-flow from the part and may determine gangrene of tissues already devitalised.

Dry cold may be employed by means of ice-bags, or by Leiter's lead tubes through which a continuous stream of ice-cold water is kept flowing.

A milder form of employing cold is by means of *evaporating lotions*. A thin piece of lint or gauze is applied over the inflamed part and is kept constantly moist with the lotion, the dressing being left freely exposed to allow of continuous evaporation. A useful evaporating lotion is made up as follows:—Take of chloride of ammonium, half an ounce; rectified spirit, one ounce; and water, seven ounces.

Heat is indicated in the later stages of inflammation, especially when deep-seated parts are affected. It is best employed by means of a *fomentation*. A piece of flannel or lint is wrung out of very hot water or antiseptic lotion (1 in 40 or 1 in 60 carbolic) and applied under a sheet of macintosh. Fomentations should be renewed as often as they cool. An ordinary india-rubber bag, filled with hot water and fixed over the fomentation, by retaining the heat, obviates the necessity of frequently changing the application. The addition of a few drops of laudanum sprinkled on the flannel has a soothing effect.

Lead and opium lotion is a useful, soothing application employed as a fomentation.

General Treatment.—In addition to the means taken to combat inflammation, treatment includes the alleviation of certain of its results. Pain, for instance, may be relieved either by the local application of warm and moist applications, such as antiseptic or lead and opium fomentations, or by belladonna and glycerin or ichthyol ointment. The internal administration of opiates even may be necessary.

In surgical inflammations, as a rule, nothing is gained by lowering the temperature, unless at the same time the cause is removed. When severe or prolonged pyrexia becomes a source of danger, the use of hot or cold sponging, or even the cold bath, is preferable to the administration of drugs internally.

Weakness of the heart, as indicated by the condition of the pulse, is treated by the use of alcohol, digitalis, strophanthus, or strychnine, according to circumstances.

Gastro-intestinal disturbances are met by ordinary medical means; and derangements of the nervous system by the use of chloral, bromides, or other nerve sedatives.

The treatment of inflammation in special tissues and organs will be considered in the sections devoted to regional surgery.

Results of Inflammation.—Inflammation may have a fatal result in a variety of ways, the most common being the absorption of excessive doses of bacterial toxins, as in sapræmia and septicæmia. In other cases the inflamed organ, such as the brain, the lungs, or the kidneys, may be so essential to life that the continued interference with its function proves fatal.

On the other hand, inflammation may end in complete recovery, in which case *resolution* is said to take place. The removal of the cause is followed by the return of the local circulation to the normal, and the reabsorption of inflammatory products.

In certain situations, notably in tendon sheaths, the cavities of joints, and the interior of serous cavities, the restoration to the normal condition is incomplete, fibrous adhesions forming between the adjacent surfaces of the inflamed structures, and remaining more or less persistent.

Finally, a condition of chronic inflammation may be established.

Chronic Inflammation.

Although the difference between acute and chronic inflammation is essentially one of degree, there are certain pathological and clinical distinctions which call for description. Chronic inflammation may result from a slow and gradual subsidence of an acute process, or it may be due to the action of the specific virus of such diseases as tubercle, syphilis or other chronic infective process, which seldom gives rise to acute manifestations.

The tendency of chronic inflammation is towards the formation of granulation tissue, which goes on to form new connective tissue. Suppuration is rare in chronically inflamed tissues, unless from the fresh introduction of infective organisms.

The most prominent *clinical* feature of chronic inflammation is swelling, which is of a firm, elastic character, being due to the formation of young fibrous tissue. Pain is not marked, although tenderness is usually present; and heat and discoloration are but slight. General constitutional disturbance is absent or inconsiderable, and the interference with function varies in degree with the tissue or organ affected. All the clinical features depend for their severity on the particular disease with which the inflammatory process is associated.

Treatment of Chronic Inflammation.—In treating a chronic inflammation, the indications are (1) to remove the cause, and (2) to get rid of the inflammatory deposits in the tissues.

When the cause is the presence of a specific infective organism, such as the tubercle bacillus, its complete removal is only possible by operation, and if this be inexpedient at the time, our efforts must be directed to aid the tissues to resist its action.

The general hygiene of the patient must receive careful attention; and the part must be ensured complete physical and physiological rest, in such a position as will favour the blood-flow through it.

The removal of inflammatory products is stimulated by the use of *counter-irritants*, in the form of mustard leaves, blisters, or the actual cautery, according to the degree of irritation required. A mustard leaf or plaster should not be left on longer than ten or fifteen minutes, unless it is desired to produce a blister. Blistering may be produced by a *cantharidis plaster*, or by painting with *liquor epispasticus*. The plaster should be left on for from eight to ten hours, and if it has failed to raise a blister, a hot fomentation should be applied to the part. Liquor epispasticus alone, or mixed with equal parts of collodion, is painted on the part with a brush. Several paintings are often required before a blister is raised. The removal of the natural grease from the skin by ether favours the action of these applications.

The *actual cautery* is employed at a white heat, care being taken that the whole thickness of the skin is not destroyed. *Corrigan's button cautery* is employed to produce vesication, and is used at a black heat.

The internal administration of potassium iodide is often a useful adjuvant to local treatment, even in cases which are not syphilitic.

Pressure.—When the inflammatory process has been arrested, absorption of the products may be promoted by firmly-applied pressure, either by means of an elastic bandage over a moderately-thick layer of cotton-wool, or by adhesive strapping. In certain cases of joint disease, pressure, combined with counter-irritation, is employed in the form of Scott's dressing. This application consists of compound mercury ointment spread on lint, which is placed on the part and fixed in position by imbricated strips of plaster firmly applied from below upward. A suitable splint to ensure immobility of the joint is useful.

Massage.—In employing massage to promote absorption of inflammatory products, the healthy part on the proximal side of the affected area should first be firmly stroked in the direction of the venous and lymphatic flow, so as to empty the vessels. The indurated area is next rubbed, squeezed, kneaded, or tapped, to break up the inflammatory products, and then stroked—again centripetally—to effect their removal. The part of the swelling nearest the trunk is first attacked, and the process extended in a distal direction. The frequency and duration of the sittings will depend on the site, extent, and general nature of the inflammatory condition, fifteen to twenty minutes once or twice daily being found sufficient in most cases.

CHAPTER V.

SUPPURATION.

Definition—Pus—*Varieties*—Acute circumscribed abscess—*Acute suppuration in a wound*—*Acute suppuration in a mucous membrane*—Diffuse cellulitis and diffuse suppuration—*Clinical features of diffuse suppuration in different situations*—*Whitlow*—Chronic suppuration—Sinus, Fistula—Surgical fevers due to the action of bacteria—*Sapræmia*—*Septicæmia*—*Pyæmia.*

Suppuration, or the formation of pus, is one of the results of the action of certain bacteria on the tissues of the body. The invading organism is usually one of the staphylococci, less frequently a streptococcus, and still less frequently one of the other bacteria capable of producing pus, such as the bacillus coli communis, the gonococcus, the pneumococcus, or the typhoid bacillus.

So long as the tissues are in a healthy condition they are able to withstand the attacks of moderate numbers of pyogenic bacteria of ordinary virulence, but when devitalised by disease, by injury, or by inflammation due to the action of other pathogenic organisms, suppuration ensues.

Pus.—The fluid resulting from the process of suppuration is known as *pus*. In its typical form it is a yellowish creamy substance, of alkaline reaction, with a specific gravity of about 1030, and has a peculiar mawkish odour. If allowed to stand in a test-tube it does not coagulate, but separates into two layers, an upper, transparent, straw-coloured fluid, the *liquor puris* or pus serum, closely resembling blood serum in its composition, but containing less proteid and more cholesterin. It also contains leucin, tyrosin, and certain albumoses which prevent coagulation.

The solid constituents form a layer at the bottom of the tube, consisting largely of dead leucocytes and fixed tissue cells (*pus corpuscles*). Red corpuscles, micro-organisms, fibrin, fat, mucin, cholesterin crystals, and small portions of necrosed tissue are also present.

Pus cells from an *acute* abscess have a well-defined rounded outline, are colourless, and contain granular protoplasm free of fat, and multi-partite nuclei. They show amœboid movement. Those from a *chronic* or cold abscess are aggregated into clumps. These clumps consist of granular debris, the protoplasm having undergone fatty degeneration and the cells lost their outline and nuclei.

Variations from Typical Pus.—Pus from old-standing sinuses is often watery in consistence (ichorous), with a low specific gravity (1020) and few cells. Where the granulations are vascular and bleed easily it becomes sanious from admixture with red corpuscles; while if a blood-clot be broken down and the debris mixed with the pus, it contains granules of blood pigment and is said to be grumous. The *odour* of pus varies with the different bacteria producing it. Pus due to ordinary pyogenic cocci has a mawkish odour; when putrefactive organisms are present it has an extremely offensive putrid odour; when it forms in the vicinity of the intestinal canal it usually contains the bacillus coli communis, and has a fæcal odour.

The *colour* of pus also varies: when due to one or other of the varieties of the bacillus pyocyaneus it is usually of a blue or green colour; when mixed with bile derivatives or altered blood pigment it may be of a bright orange colour. In wounds inflicted with rough iron implements from which rust is deposited the pus often presents this same colour.

The pus may form and collect within a circumscribed area, constituting a localised *abscess;* or it may infiltrate the tissues over a wide area—*diffuse suppuration.*

ACUTE CIRCUMSCRIBED ABSCESS.

Any tissue of the body may be the seat of an acute abscess, and there are many routes by which the bacteria may gain access to the affected area. For example, an abscess in the integument or subcutaneous cellular tissue usually results from infection by organisms which have entered through a wound or abrasion of the surface or along the ducts of the skin; an abscess in the breast from organisms which have passed along the milk ducts opening on the nipple or along the lymphatics which accompany these. An abscess in lymphatic glands is usually due to infection passing by way of the lymphatic channels from the area of skin or mucous membrane drained by them. Abscesses in internal organs, such as the kidney, liver, or brain, usually result from infection by organisms carried in the blood-stream from some focus of suppuration elsewhere in the body, or from a lesion of the skin or mucous membrane.

Formation of an Abscess. — When virulent pyogenic bacteria settle in a part there ensues an inflammatory reaction, producing congestion and stasis in the blood-vessels, migration of leucocytes, and exudation of plasma into the surrounding tissues. The toxins produced by the bacteria induce degenerative changes in the endothelial cells of the vessel walls, in the connective-tissue corpuscles, and in the wandering leucocytes. Towards the centre of the inflamed area, where this action is most concentrated, coagulation necrosis takes place, and in the dead material thus produced the bacteria grow and multiply. By means of a digestive ferment secreted by the organisms, and probably also by phagocytic action, the necrosed tissue becomes liquefied, and a focus of pus is formed, constituting an *abscess*. Around this is a zone of coagulated or necrotic tissue ready to break down as the process extends; and this in turn is surrounded by a ring of inflamed tissue which acts as an obstacle to the further spread of the bacteria.

The pus thus formed is, owing to the swelling and condensation of the parts around, under considerable pressure, which causes it to spread along the lines of least resistance. In the case of a subcutaneous abscess the pus usually spreads directly towards the surface, and "points," as it is called. Where the abscess points, the skin becomes soft and thin, and sloughs form at one or more spots, giving exit to a quantity of pus.

An abscess forming in the deeper planes is prevented from pointing directly to the surface by the firm fasciæ and other fibrous structures. The pus therefore tends to burrow along the line of the blood-vessels and in the connective-tissue septa till it either finds a weak spot or causes a portion of fascia to slough, and so reaches the surface. Accordingly many abscess cavities resulting from deep-seated suppuration are of irregular shape, with pouches and loculi in various directions—an arrangement which seriously interferes with their successful treatment by incision and drainage.

The relief of tension which follows the bursting of an abscess, the removal of irritation by the escape of pus, and the throwing out of bacteria and toxins, allow the tissues once more to assert themselves. Granulation tissue forms round the abscess cavity, gradually increases in amount, and becomes organised into fibrous tissue, which eventually fills the gap resulting from the destruction of the original tissues. Epithelium covers the granulating surface and the scar is thus completed. The details of this process have already been described under repair.

Clinical Features of an Acute Circumscribed Abscess.—The formation of an acute abscess is always preceded and accompanied by the presence of inflammation, and the clinical characters of the two conditions are blended. Rigors, increased elevation of temperature, progressive leucocytosis, and sweating mark the transition between inflammation and suppuration. In some cases an increasing leucocytosis is the only available evidence that a suppurative process is spreading. On the other hand, if the toxæmia is intense the leucocytes may diminish in number and even fall below the normal.

The local symptoms vary with the seat of the abscess. When it is situated superficially, for example, in the breast tissue, the affected area is hot, the redness of inflammation gives place to a dusky purple colour, with a pale, sometimes yellow, spot where the pus nears the surface. The swelling increases in size, the firm brawny centre becomes soft, projects as a cone beyond the level of the rest of the swollen area, and is usually surrounded by a zone of induration.

By placing the fingers of one hand over a part of the swelling, and gently tapping or pressing at another part, a fluid wave may be detected in the softened area. This is known as *fluctuation*, and when present is a certain indication of the existence of fluid in the swelling. Its recognition, however, is by no means easy, and various fallacies are to be guarded against in applying this test clinically. When, for example, the walls of the abscess are thick and rigid, or when its contents are under excessive tension, the fluid wave cannot be elicited. On the other hand, a sensation closely resembling true fluctuation may often be recognised on palpating œdematous tissues, certain soft solid tumours, such as vascular sarcomata, and in some cases of aneurysm.

When pus has formed in deeper parts, and before it has reached the surface, œdema of the overlying skin is very frequently present, and the skin pits on pressure.

With the formation of pus the continuous burning or boring pain of inflammation assumes a throbbing character, with occasional sharp, lancinating twinges. Should doubt remain as to the presence of pus, recourse may be had to the use of an exploring or aspirating needle, care being taken that the bore of the needle is wide enough to permit of the flow of pus through it.

Differential Diagnosis of Acute Abscess.—A practical difficulty which frequently arises is to decide whether or not pus has actually formed. When an acute inflammation lasts for four or five days without showing signs of abatement, suppuration is almost certain to ensue. Marked œdema of the skin and the occurrence of rigors indicate the formation of pus. When any doubt remains it is best for the patient to assume the presence of pus and to act accordingly.

There are cases on record where rapidly-growing sarcomatous and angiomatous tumours, aneurysms, and the bruises which occur in hæmophylics, have been mistaken for acute abscesses and incised.

Treatment of Acute Abscess.—The dictum of John Bell, "Where there is pus, let it out," must be rigidly and promptly acted upon. The extent and situation of the incision will be regulated by the size of the abscess and its anatomical relations, but in all cases it should be sufficiently free to ensure thorough emptying of the cavity and to admit of efficient drainage. Large abscesses should be drained by glass or rubber tubes; smaller abscesses by strands of iodoform worsted or of protective.

In some cases the cavity should be laid freely open in its whole extent, stuffed with iodoform gauze, and treated by the open method. Washing out an abscess cavity is seldom advisable. Squeezing out the pus is also to be avoided lest the protective zone be broken down and the pus diffused into the surrounding tissues.

The importance of adopting antiseptic precautions in opening an abscess can scarcely be exaggerated, and the rapidity with which healing occurs when the access of fresh bacteria is prevented is in marked contrast to what occurs when antiseptic precautions are neglected and further infection is allowed to take place. The wound should be dressed the next day, and the tube shortened, in the case of a rubber tube, by cutting off a portion of its outer end. On the second day or later, according to circumstances, the tube is removed, and after this the dressing need not be repeated oftener than every second or third day.

Where pus has formed in relation to important structures,—as, for example, in the deeper planes of the neck,—*Hilton's method* of opening the abscess may be employed. An incision is made through the skin and fascia, a grooved director is gently pushed through the deeper tissues till pus escapes along its groove, and then the track is widened by passing in a pair of dressing forceps and expanding the blades. A tube is introduced, and the subsequent treatment carried out as in other abscesses. When the tube lies in proximity to a large blood-vessel, care must be taken not to leave it in position long enough to cause ulceration of the vessel wall by pressure.

Acute suppuration in lymphatic glands, bones, joints, serous cavities, and internal organs will be described later.

Acute Suppuration in a Wound.—When a wound is infected by pyogenic bacteria, the pathological changes already described as occurring in the formation of a circumscribed abscess take place, modified by the fact that the pus can reach the surface by bursting through the line of incision. The parts around become red, swollen, œdematous, and painful. The stitches are tightened by the swelling, and cut into the tissues. At last the feebly-united edges of the wound separate, and the pus escapes. If the stitches be now cut, pus escapes more freely, the wound gapes, and its surfaces are found to be covered with granulations bathed in pus. The surrounding inflammation subsides, the discharge of pus lessens, and healing takes place by the formation of granulation tissue—the so-called "healing by second intention."

While the pus is forming the temperature rises, and a rigor may occur. The free opening up of the wound is almost immediately followed by a fall in the temperature.

Wound infection may take place from *catgut* which has not been perfectly sterilised. The local and general reactions in these cases may be very slight, and, as a rule, do not appear for seven or eight days after the operation, and, it may be, not till after the wound has healed on the surface. The pus is thick and dark, and is strictly localised to the part of the wound where catgut was employed for stitches or ligatures. It usually shows little tendency to spread throughout the whole wound, but the infected part is often long of healing.

When suppuration occurs in connection with buried sutures of unabsorbable materials, such as silk, silkworm gut, or silver wire, it is apt to persist till the foreign material is cast off or removed.

Suppuration may occur along the line of skin stitches, producing *stitch abscesses.* The infection may arise from the material used, especially catgut or silk, or, more frequently perhaps, from the growth in the patient's skin of staphylococcus albus when the part has been imperfectly disinfected.

Acute Suppuration of a Mucous Membrane.—When pyogenic organisms gain access to a mucous membrane, such as that of the bladder, urethra, or middle ear, the usual phenomena of acute inflammation and suppuration ensue, followed by the discharge of pus from the free surface. It would appear that the most marked changes take place in the sub-mucous tissue, causing the covering epithelium in places to die and leave small superficial ulcers. When mucous glands are present in the membrane the pus is mixed with mucus—*muco-pus.*

DIFFUSE CELLULITIS AND DIFFUSE SUPPURATION.

Cellulitis is an acute inflammatory affection resulting from the introduction of some organism—commonly the *streptococcus pyogenes*—into the cellular connective tissue of the integument, intermuscular septa, tendon sheaths, or other structures. The process always begins in a wound, although this may be small, superficial, and insignificant, such as a pin-prick, a scratch, or a crack under a nail, and the wound may have been healed for some time before the inflammation sets in. The cellulitis, also, may develop at some distance from the seat of inoculation, the organisms having travelled by the lymphatics. While it is true that the inflammation may resolve without the formation of pus, such a result is exceptional, and it is convenient to consider the preliminary inflammation—the cellulitis—and the resulting suppuration together.

The virulence of the organisms, the loose, open nature of the tissues in which they develop, and the free lymphatic circulation by means of which they are spread, tend to make the resulting inflammatory and suppurative processes become diffuse. Sometimes numbers of cocci are carried for a considerable distance from the primary area before they are arrested in the lymphatics, and thus several patches of inflammation may appear with healthy areas between.

As a result of the virulence of the bacteria and their toxins, in many cases there is sloughing of considerable portions of tissues of low vitality, such as fat, fascia, or tendon. The pus infiltrates the meshes of the cellular tissue, but if the process continue for some time it may collect and form distinct circumscribed abscesses which eventually point.

Clinical Features.—The inflammatory reaction in cases of diffuse cellulitis is severe, and is usually ushered in by a distinct chill or even a rigor, while the temperature rises to 103°, 104°, or 105° F. The pulse is proportionately increased in frequency, and is small, feeble, and often irregular. The face is flushed, the tongue dry and brown, and the patient may become delirious, especially during the night. Leucocytosis is present in cases of moderate severity. In very mild cases the reaction may be insufficient to cause leucocytosis; while in very severe cases the virulence of the toxins prevents reaction taking place, and leucocytosis is absent.

The local manifestations vary with the relation of the seat of the inflammation to the surface. When the superficial cellular tissue is involved, the skin assumes a dark bluish-red colour, is swollen, œdematous, and the seat of burning pain. To the touch it is firm, hot, and tender. When the primary focus is in the deeper tissues, the general constitutional disturbance is aggravated, while the local signs are delayed, and only become prominent when pus forms and approaches the surface. It is not uncommon for blebs containing dark serous fluid to form on the skin. The inflammation frequently spreads along the line of the main lymphatic vessels of the part (*septic lymphangitis*), and may reach the lymphatic glands (*septic lymphadenitis*).

With the formation of pus the skin becomes soft and boggy at several points, and eventually breaks, giving exit to a small quantity of thick, grumous discharge. Sometimes several small collections under the skin fuse, and a distinct abscess is formed, in which fluctuation can be detected. Occasionally gases are evolved in the tissues, giving rise to emphysema. It is very common for portions of fascia, ligaments, or tendons to slough, and this may often be recognised clinically by a peculiar crunching or grating sensation transmitted to the finger on making firm pressure on the part.

Unless evacuated by incision, the pus, travelling along the lines of least resistance, tends to point at several places on the surface, or to open into joints or other cavities.

Prognosis.—It is in cases of diffuse suppurative cellulitis that *septicæmia* occurs in its most aggravated forms. The toxins of the streptococci are exceedingly virulent, and induce local death of tissue so rapidly that the protective emigration of leucocytes fails to take place. The passage of masses of free cocci in the lymphatics, or of septic emboli in the blood vessels, not infrequently leads to the formation of *pyæmic abscesses* in vital organs, such as the brain, lungs, liver, kidneys, or other viscera. *Hæmorrhage* from suppurative perforation of large arterial or venous trunks may take place and prove dangerous to life.

Treatment.—The treatment of diffuse cellulitis is *early and free incision* of the affected area. It is not necessary, nor even advisable, to wait until there is distinct evidence of pus formation before using the knife, as incision will limit, or may even prevent, suppuration. If one incision does not command the whole area involved, others must be made, care being taken that they are placed so as not to interfere unduly with vessels and nerves. The pus is gently squeezed from the meshes of the tissues, and, where it is deemed advisable, the whole surface of the wound may be swabbed over with pure carbolic acid. Drainage tubes are inserted, or iodoform gauze lightly packed into the wound, and an ordinary antiseptic dressing applied, to be renewed at least once daily until granulations are formed and the risk of further spread is past.

In cases where the temperature remains raised, and other signs of septic absorption persist after incisions have been made, much benefit may result from the *continuous irrigation* of the part by a slow, steady stream of a mild antiseptic lotion, at the body temperature, such as boracic acid, or permanganate of potash. Frequent washing with sulphurous acid or peroxide of hydrogen (10 vols. strength) has been found to be of value in such cases.

The method of treating these cases by *continuous immersion* in a water-bath containing antiseptics has its advocates, but it is a method which is very liable to be misused and to do harm.

Elevation of the affected part diminishes the passive œdema and the pain ; but it is necessary to take care that it in no way interferes with drainage, and that it does not facilitate the spread of the pus farther up the limb. A suitably arranged splint often adds to the comfort of the patient.

The rapidity with which the process is arrested and repair takes place after prompt and vigorous treatment is often remarkable.

Massage, passive movement, hot and cold douching, and other measures, may be necessary to get rid of the chronic œdema, adhesions of tendons, and stiffness of joints which so often remain after cellulitis.

In all cases the toxæmia must be counteracted by the administration of quinine, strychnine, iron, alcoholic stimulants, and by suitable nourishment.

In a certain number of cases due to infection by streptococci, anti-streptococcic serum may be useful.

In a few rare cases amputation well above the seat of disease may, by removing the source of toxin production, offer the only means of saving the patient's life.

SUPPURATIVE CELLULITIS IN DIFFERENT SITUATIONS.

Whitlow.—Whitlow is a convenient clinical term applied to an acute inflammation, usually followed by suppuration, in the cellular tissue of the finger. The point of infection is often of a very trivial character—a pin-prick, a splinter of wood, a scratch, or even an almost imperceptible lesion of the skin. There are several clinical varieties of whitlow.

In the most superficial variety pus forms between the rete Malpighi and the stratum corneum of the skin, the latter being raised as a blister—*purulent blister*—in which fluctuation can be detected. When the pus forms in relation to the nail,—which corresponds to the stratum corneum,—it raises the nail also, and the yellow pus is often visible through it.

There is some local heat and discoloration, and considerable pain and tenderness, but little or no constitutional disturbance. Superficial lymphangitis may extend a short distance up the hand. By clipping away the raised epidermis and nail the pus is evacuated, and under an antiseptic dressing healing speedily takes place.

Another variety met with among those who handle septic material occurs in the angle between the nail and the skin, and is due to the introduction of septic matter at the nail fold (Fig. 9). A small focus of suppuration forms under the nail, with swelling and redness of the nail fold, causing intense pain and discomfort, and producing a constitutional reaction out of all proportion to the local lesion.

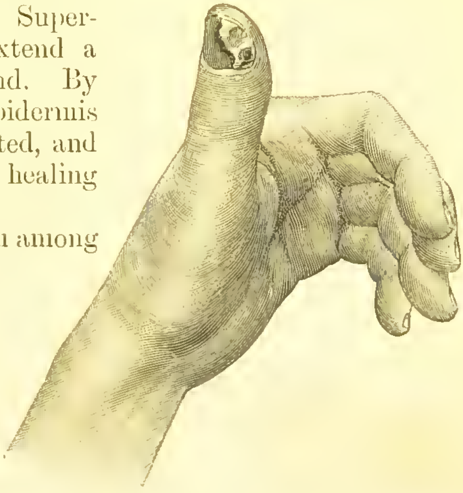

FIG. 9.—Whitlow due to septic infection at lateral nail fold. A portion of nail has been removed.

To allow the pus to escape, it is necessary, under local anaesthesia, to cut away the nail fold as well as the portion of nail in the affected area, or, it may be, to remove the nail entirely. Unless this is done very freely granulations spring up and interfere with drainage, and the condition becomes very persistent.

When the bacteria reach the subcutaneous tissue the condition becomes more serious, as it may result in sloughing of the pulp of the finger. Necrosis of the one or other of phalanges and destruction of the associated joints are not uncommon. The inflammation may spread to the flexor sheath and tendon, and thence into the hand and forearm. All the local signs of inflammation are well marked, and there is considerable constitutional disturbance, the temperature often reaching 101° or 102° F.

In more severe cases the main incidence of the disease is on the *flexor tendons and their sheaths.* The whole finger becomes red, painful, and swollen, the swelling spreading to the back of the hand, which becomes soft and puffy. The thick cuticle of the palm and the dense palmar fascia prevent swelling appearing on the front of the hand till pus is nearing the surface. On account of the anatomical arrangement of the tendon sheaths the process may spread into the forearm—directly in the case of the thumb and little finger, and after invading the palm in the case of the other fingers—and there give rise to a diffuse suppurative cellulitis with sloughing of fasciæ and tendons (Fig. 10).

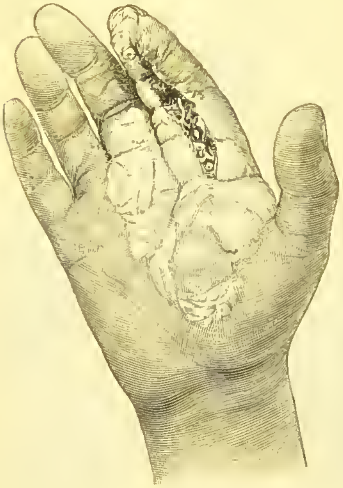

Fig. 10.—Whitlow in Sheath of Flexor Tendon of Index Finger with Abscess spreading into Palm.

Sometimes the excessive tension and virulent toxins induce actual gangrene of the distal part of a finger; and it is not uncommon for the joints about the wrist to be invaded. Impaired movement of the tendons and joints is a common sequel to this variety of cellulitis.

The *treatment* consists in early and free incision, with the aid of a local anæsthetic, of the inflamed or suppurating areas, so as to obtain efficient drainage. During convalescence passive movements and massage must be perseveringly employed to prevent the formation of adhesions and resulting stiffness, and for this purpose a general anæsthetic (chloride of ethyl or nitrous oxide) is often necessary.

In exceptional cases the process specially involves the bones, leading to necrosis, the formation of sinuses, and persistent suppuration. In such cases the joints are usually implicated also, and lateral mobility and grating are elicited on palpation. Recovery does not take place until the dead bone is removed, and the usefulness of the fingers is often seriously impaired by the joints remaining stiff. This may render amputation advisable when a stiff finger is likely to interfere with the patient's occupation.

Conditions similar to whitlow occur in the *toes* and *sole of the foot*, but with much less frequency than in the fingers and hand.

Cellulitis of the forearm is usually a sequel to one of the deeper varieties of whitlow. Serious impairment of usefulness in the limb often results from sloughing of fasciæ and tendons or from adhesions. Implication of the carpal and wrist joints, with necrosis of bone, is also common, unless incisions are made early to prevent it.

In the *region of the elbow joint* cellulitis is common around the olecranon process. It may originate as a septic bursitis, or may invade the olecranon bursa secondarily. In exceptional cases the elbow joint is involved also.

Cellulitis of the *axilla* usually originates in the lymphatic glands, or it may spread from the neck. The process may pass down the arm, on to the chest wall, or into the shoulder joint.

In the *region of the ankle* cellulitis is not common; but *around the knee* it frequently occurs in relation to the prepatellar bursa and in the popliteal lymphatic glands, and may endanger the knee joint. It is also met with in the *groin* following on inflammation and suppuration of the glands, and may implicate the femoral vessels. Cellulitis of the scalp, orbit, neck, pelvis, and perineum will be considered with the diseases of these regions.

CHRONIC SUPPURATION.

The formation of a chronic or cold abscess is, in the great majority of instances, the result of the action of the tubercle bacillus. At the same time, it is true that pus may form slowly from the breaking down of a syphilitic gumma. In certain rare cases, especially of bone disease and in the breast, pyogenic bacteria act so slowly that the resulting abscesses may justly be called chronic. It is, however, more convenient to study this form of suppuration with tuberculosis, and the reader is referred to the chapter on that subject.

LOCAL RESULTS OF SUPPURATION WHEN HEALING IS PREVENTED—SINUS AND FISTULA.

A **Sinus** is a track leading from a focus of suppuration in the substance of the tissues to the surface of the skin or of a mucous membrane. There are two varieties of sinus met with clinically—that which is prevented from healing by mechanical causes; and the tuberculous sinus.

In the first variety, the mechanical obstacle to closure may be the presence of a foreign body, such as a piece of dead bone, a septic ligature, or a bullet in the abscess cavity; the constant escape of pus which has not a sufficiently free outlet; or merely want of rest to the affected part. The sinus is lined by ordinary granulation tissue, and when a foreign body is present, a mass of redundant granulations often projects from the external opening. In sinuses of long standing there is often a considerable amount of scar tissue around them, the contraction of which drags the opening of the sinus below the level of the surrounding skin. The *treatment* in these cases is the removal of the cause, by enlarging the opening so as to be able to remove any foreign substance and to permit of disinfection as well as of more thorough drainage. Any muscles through or between which the sinus passes must be kept at rest by suitable splints, or by division of their fibres. The sinus may be scraped, and treated with pure carbolic acid or the thermo-cautery, and then stuffed with iodoform worsted, so as to encourage healing from the bottom. Sinuses in scar tissue may be treated by complete excision, the raw surfaces left being approximated by stitches.

The *tuberculous sinus* fails to close because the destructive process is going on in its walls. These are lined with granulations which are infected with bacilli and studded with tuberculous nodules. As a rule the primary focus of tubercle in bone, joint, or gland is still active, and the sinus is a necessary avenue for the escape of discharge. These sinuses, which are often long and tortuous, are treated by thorough removal of all the tuberculous tissue from which they originate and by which they are lined, and by thorough disinfection with carbolic acid or some other powerful and penetrating antiseptic.

Packing with iodoform worsted is a useful form of dressing.

A **Fistula** is an abnormal canal passing from a mucous surface to the skin or to another mucous surface. Fistulæ resulting from suppuration usually occur near the natural openings of mucous canals—for example, on the cheek, as a salivary fistula; beside the angle of the eye, as a lachrymal fistula; near the ear, as a mastoid fistula; or close to the anus, as a fistula-in-ano. Intestinal fistulæ are sometimes met with in the abdominal wall after strangulated hernia, operations for appendicitis, tuberculous peritonitis, and other conditions. In the perineum they frequently complicate strictures of the urethra.

Fistulæ also occur between the bladder and vagina (vesico-vaginal), or between the bladder and the rectum (recto-vesical).

The guiding principle in treating a fistula is to enable the discharge to pass more readily by the natural than by the abnormal route. When this is done, spontaneous closure of the fistulous opening tends to take place in most cases, but in others complicated plastic operations may be necessary to effect a cure.

Congenital fistulæ, such as occur in the neck from imperfect closure of branchial clefts, or in the abdomen from unobliterated fœtal ducts, such as the allantois or Meckel's diverticulum, will be described in their proper places.

SURGICAL FEVERS DUE TO THE ACTION OF BACTERIA.

We have here to consider certain fevers, Sapræmia, Septicæmia, and Pyæmia, which, although their clinical manifestations are widely different in many respects, are all directly associated with the action of bacteria, and are fundamentally of the same nature.

Sapræmia, or septic intoxication, is the name applied to a form of septic poisoning resulting from the absorption into the blood of the toxic products of bacteria. These products are of the nature of alkaloids. They act immediately on their entrance into the circulation, and produce effects in direct proportion to the amount absorbed. As the poison is gradually eliminated from the body the symptoms abate, and if no more be introduced they disappear. Sapræmia in these respects, therefore, is comparable to poisoning by any other form of alkaloid, such as strychnine or morphin.

Clinical Features.—The symptoms of sapræmia seldom manifest themselves within twenty-four hours of an operation or injury, because it takes some time for the bacteria to produce a sufficient dose of their poisons. The onset of the condition is marked by a feeling of chilliness, sometimes amounting to a rigor, and a rise of the temperature to 102°, 103°, or 104° F., with slight morning remissions (Fig. 1). The heart's action is markedly depressed, and the pulse is soft and compressible. The appetite is lost, the tongue dry, and covered with a thin brownish-red fur, so that it has the appearance of "dried beef." Vomiting of dark coffee-ground material and diarrhœa are often prominent features. The urine is scanty and loaded with urates. Death is usually impending when the skin becomes cold and clammy, the mucous membranes livid, the pulse feeble and fluttering, the discharges involuntary, and when a low form of muttering delirium is present.

A local focus of septic infection is always present in some part of the body,—it may be in the region of a compound fracture, in an operation wound, or in the cavity of the uterus.

Prognosis.—As the symptoms are due to definite doses of the toxin, the prognosis depends upon the amount already absorbed, the resisting powers of the individual, and the possibility of arresting further absorption. If the decomposing material is at once removed, and if a lethal dose of the poison has not already entered the circulation, the prognosis is good, and the symptoms begin to subside as soon as the supply is cut off.

The *prophylaxis* of sapræmia consists in excluding bacteria by every surgical means, and in preventing the accumulation of any material in which they may flourish should they gain an entrance.

Treatment.—The first and clearest indication in treatment is the immediate and complete removal of the infected material. The wound must be freely opened, all blood-clot, discharge, or necrosed tissue thoroughly removed, and the area disinfected, by washing with sterilised salt solution, peroxide of hydrogen, or boracic acid. Stronger lotions are to be avoided as likely to depress the tissues on the surface of the wound, and so to interfere with protective phagocytosis. On account of its power of neutralising toxins, iodoform is a useful application in these cases, and is best employed by packing the wound with iodoform gauze, and treating it by the open method, if this is possible.

To aid the patient in getting rid of the poison already absorbed, general stimulants are useful. In serious cases alcohol in the form of brandy or whisky, in hourly half-ounce doses; hypodermic injections of ether, strychnine (1/60th to 1/30th gr. every hour), or digitalin (1/100th gr. every hour), may be required. The kidneys should be flushed by administering large quantities of bland fluids. The vomiting can sometimes be checked by effervescing drinks such as citrate of caffein, or by dilute hydrocyanic acid and bismuth. In severe cases, and especially when the vomited matter resembles coffee-grounds from admixture with altered blood—the so-called post-operative hæmatemesis,—the most certain means of arresting the vomiting is by washing out the stomach. The patient must be fed with nourishing and easily assimilated food.

Chronic Sapræmia or Hectic Fever.—Hectic fever differs from acute sapræmia merely in degree. It usually occurs in connection with such tuberculous conditions as bone or joint disease, psoas abscess, or empyema, which have opened externally, and have thereby become infected with pyogenic organisms. It is gradual in its development, and is of a mild type throughout.

The pulse is small, feeble, and compressible, and the temperature rises in the afternoon or evening to 102° or 103° F. (Fig. 2), the cheeks becoming characteristically flushed. In the early morning the temperature suddenly falls to normal or below it, and the patient breaks into a profuse perspiration which leaves him pale, weak, and exhausted. He becomes rapidly and markedly emaciated (Fig. 11), even although in some cases the appetite remains good and is even voracious.

The poisons circulating in the blood produce *waxy degeneration* in certain viscera, notably the liver, spleen, kidneys, and intestines. The process begins in the arterial walls and spreads thence to the connective-tissue structures, causing marked enlargement of the affected organs. Albuminuria, ascites, œdema of the lower limbs, clubbing of the fingers, and diarrhœa are among the most prominent symptoms of this condition.

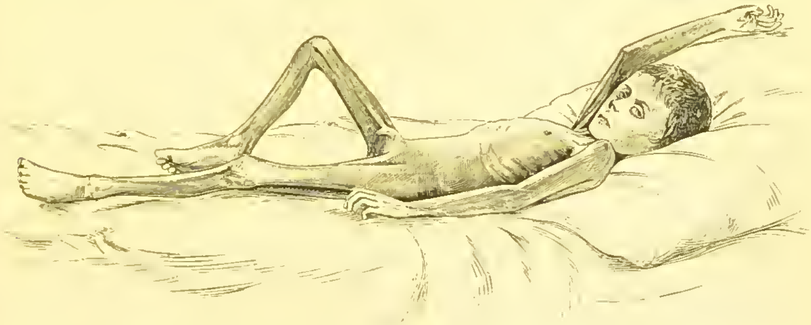

FIG. 11.—Extreme Emaciation accompanying Hectic Fever secondary to Sacro-iliac Disease in a boy aged 8, who subsequently recovered.

The *prognosis* in hectic fever depends on the completeness with which the further absorption of toxins can be prevented. In many cases this can only be effected by an operation which provides for free drainage, and, if possible, the removal of infected tissues. The resulting wound is best treated by the open method. Even advanced waxy degeneration does not contra-indicate this line of treatment, as the diseased organs usually recover when the patient survives the operation. Sweating, diarrhœa, albuminuria, and the other special symptoms are to be met by medical means.

Septicæmia.—This form of septic poisoning is the result of the action of pyogenic bacteria, which not only produce their toxins at the primary seat of infection, but themselves enter the blood-stream and are carried to different viscera, where they settle and produce further effects.

Clinical Features.—There may be an incubation period of some hours between the infection and the first manifestation of acute septicæmia. In such conditions as acute osteo-myelitis or acute perforative peritonitis we see the most typical clinical pictures of this condition. The onset is marked by a chill, or a rigor, which may be repeated, while the temperature rises to 103° or 104° F. In very severe cases the temperature may be subnormal throughout. The virulence of the toxins may prevent leucocytosis occurring. It is in the pulse that we have our best guide as to the severity of the condition. If the pulse remain firm, full, and regular, and does not exceed 110 or even 120, while the temperatnre is moderately raised, the outlook is hopeful; but when the pulse becomes small and compressible, and reaches 130 or more, especially if at the same time the temperature is low, a grave prognosis is indicated. The tongue is often dry, and coated with a black crust down the centre, while the sides are red. It is a good omen when the tongue becomes moist again. Thirst is most distressing, especially in septicæmia of intestinal origin. Persistent vomiting of dark-brown material whenever fluids are taken is often present, and diarrhœa with blood-stained stools is not uncommon. The urine is small in amount, and contains a large proportion of urates. As the disease advances, the respiration becomes shallow and laboured, the face of a dull ashy grey, the nose pinched, and the skin cold and clammy. Capillary hæmorrhages sometimes take place in the skin or mucous membranes; and in a certain proportion of cases cutaneous eruptions simulating those of scarlet fever or measles appear, and are apt to lead to errors of diagnosis. In other cases there is slight jaundice. The mental state is often one of complete apathy, the patient failing to realise the gravity of his condition; sometimes there is delirium.

The *prognosis* is always grave, and depends on the possibility of complete disinfection of the seat of toxin formation, and the reserve force the patient has to carry him over the period during which he is eliminating the poison already in circulation.

The only *prophylaxis* of septicæmia possible to the surgeon consists in the rigorous application of antiseptic methods in all surgical procedures. It has been suggested by Watson-Cheyne that the anti-streptococcic serum should be injected as a prophylactic before operation in cases where there is reason to fear streptococcal infection, and where rigid aseptic precautions cannot be enforced, as in the mouth or rectum.

Treatment.—Once the condition is firmly established, little can be done. The wound must be opened up, purified by painting the surfaces with undiluted carbolic acid, and then packed with iodoform gauze or worsted. In abdominal cases the peritoneal cavity should be washed out with sterilised salt solution. In some cases salt solution may be injected with great benefit directly into the veins or into the subcutaneous tissue. When the toxin is of streptococcal origin, recourse may be had to the injection of *anti-streptococcic serum*. Amputation of a limb for septicæmia is a last resource, and too often a forlorn hope.

The general treatment is carried out on the same lines as in sapræmia.

Pyæmia is a form of septic poisoning characterised by the development of secondary foci of suppuration in different parts of the body by metastasis. Toxins are thus introduced into the blood, not only at the primary seat of infection, but also from each of these metastatic collections. Like septicæmia, this condition is due to pyogenic bacteria, the *streptococcus pyogenes* being the commonest organism found. The primary infection is usually in a surface wound, but cases occur in which the point of entrance of the bacteria is not discoverable. The dissemination of the organisms takes place through the medium of septic emboli which form in a thrombosed vein in the vicinity of the original lesion, and breaking loose are carried thence in the blood-stream. These emboli lodge in the minute vessels of the lungs, spleen, liver, kidneys, pleura, brain, synovial membranes, or cellular tissue, and the bacteria they contain give rise to inflammatory changes which end in suppuration. Secondary abscesses are thus formed in those parts, and these in turn may be the starting-point of new emboli which give rise to fresh areas of pus formation. The organs above named are the commonest situations of pyæmic abscesses, but they may also occur in the bone marrow, the substance of muscles, the heart and pericardium, lymphatic glands, subcutaneous tissue, or, in fact, in any tissue of the body. Septic organisms circulating in the blood are very prone to lodge on the valves of the heart and give rise to endocarditis.

Clinical Features.—Before antiseptic surgery was practised, pyæmia was a common complication of surgical wounds. In the present day it is not only infinitely less common, but appears also to be of a less severe type. Its rarity and its mildness may be related as cause and effect, because it is found that pyæmia contracted from a pyæmic patient is more virulent than that from any other source.

Pyæmia seldom develops within a week of an operation or injury, but may appear any time thereafter. The first sign is a violent rigor lasting for perhaps half an hour, during which time the temperature rises to 103°, 104°, or 105° F. In the course of an hour it begins to fall again, and the patient breaks into a profuse sweat. The temperature may fall several degrees, but seldom reaches the normal. In a few days there is a second rigor with rise of temperature, and another remission, and such attacks may be repeated at diminishing intervals during the course of the illness (Figs. 4 and 5). In severe cases the disease proves fatal in ten days or a fortnight, but it often runs a much longer course, lasting for weeks or even months.

The pulse tends to remain abnormally rapid even when the temperature falls nearly to normal. Anorexia, nausea, vomiting, profuse diarrhœa, and marked emaciation indicate the gastro-intestinal derangement. Erythematous, vesicular, or pustular rashes often occur. The seat of the secondary abscesses determines the other symptoms. Jaundice accompanies abscess of the liver; the signs of pleurisy and empyema follow infection of the pleura; hæmoptysis with signs of pneumonia is associated with secondary abscesses in the lungs; and albuminuria with blood casts in the urine indicate infection of the kidney. Meningitis and sinus thrombosis give rise to cerebral symptoms; and involvement of synovial membranes to those of suppuration in joints.

Secondary infection of the parotid gland frequently occurs and gives rise to a suppurative parotitis. This condition is associated with severe pain, gradually extending from behind the angle of the jaw on to the face. There is also swelling over the gland, and eventually suppuration and sloughing of the gland tissue and overlying skin.

Secondary abscesses in the lymphatic glands, subcutaneous tissue, or joints are often very insidious and painless in their development, so that they may only be discovered by the swelling which results. When the pus is evacuated, healing often takes place with remarkable rapidity, and with little interference with function.

Prognosis.—While the prognosis in acute pyæmia is always grave, it is much less hopeless than it once was, a considerable proportion of the patients recovering. In the acute cases death is due to toxæmia, and in those that are chronic, to exhaustion and waxy disease following on prolonged suppuration.

Treatment.—The rational treatment is in the first place to arrest the dissemination of the infective material from the primary source of infection. In some cases an attempt may be made to interrupt the channel along which the septic emboli spread by ligaturing or resecting the main vein of the affected part. This is seldom feasible, however, except in the case of the internal jugular vein for lateral sinus phlebitis. The wound must be thoroughly disinfected, its surface sponged with undiluted carbolic acid, and then packed with iodoform gauze or worsted until granulations form. When this is impracticable or inefficient, amputation may be called for.

Secondary abscesses must be opened and drained whenever possible.

The constitutional treatment is conducted on the same general lines as in other forms of septic infection. Quinine in large doses has a special reputation as an internal antiseptic and antipyretic in this disease.

CHAPTER VI.

ULCERATION AND ULCERS.

Definitions—Clinical examination of an ulcer—The healing sore.—Classification of ulcers—A. According to cause: *Traumatism, Imperfect circulation, Imperfect nerve-supply, Constitutional causes*—B. According to condition: *Healing, Stationary, Spreading.*—Treatment—Skin Grafting.

The process of *ulceration* may be defined as the molecular or cellular death of tissue taking place on a free surface. It is essentially of the same nature as the process of suppuration, only that the purulent discharge, instead of collecting in a closed cavity and forming an abscess, at once escapes on the surface.

An *ulcer* is an open wound or sore in which there are present certain conditions tending to prevent it undergoing the natural process of repair. Of these, one of the most important is the presence of pathogenic bacteria, which by their action not only prevent healing, but so irritate and destroy the tissues as to lead to an actual increase in the size of the sore. Interference with the nutrition of a part by œdema or venous congestion may impede healing; as may also *induration* of the area surrounding an ulcer, by preventing the contraction which is such an important factor in repair. Defective innervation such as occurs in cases of spinal disease or injury, in infantile paralysis, and in other nervous conditions, also plays an important part in delaying repair in ulcers. In certain constitutional conditions too—for example, Bright's disease, diabetes, or syphilis—the vitiated state of the tissues is an impediment to repair. Mechanical causes such as unsuitable dressings or ill-fitting appliances may also act in the same direction.

Clinical Examination of an Ulcer.—In examining any ulcer we observe—(1) Its *base* or *floor*, noting the presence or absence of granulations, their disposition, size, colour, vascularity, and whether depressed or elevated in relation to the surrounding parts. (2) The *discharge* as to quantity, consistence, colour, composition, and odour. (3) The *edges*, noting particularly whether or not the marginal epithelium is attempting to grow in over the surface; also their shape, regularity, thickness, and whether undermined or overlapping, everted or depressed. (4) The *surrounding tissues* as to whether they are congested, œdematous, inflamed, indurated, or otherwise. (5) Whether or not there is *pain* or tenderness in the raw surface or its surroundings. (6) The *part of the body* on which it occurs, because certain ulcers have special seats of election—for example, the varicose ulcer in the front of the leg, the perforating ulcer on the foot, and so on.

The Healing Sore.—When a portion of skin has been excised aseptically—for example, in skin-grafting or in removing a small cutaneous tumour—the raw surface left is soon covered over with a layer of coagulated blood and lymph. In the course of a few days this is replaced by the growth of *granulations*, which are of uniform size, of a pinkish-red colour, and moist with a slight serous exudation containing a few dead leucocytes. They grow until they reach the level of the surrounding skin, and so fill the gap with a fine velvety mass of granulation tissue. At the edges the young epithelium may be seen spreading in over the granulations as a fine bluish-white pellicle, which gradually covers in the sore, becoming paler in colour as it thickens, and eventually forming the smooth, non-vascular covering of the cicatrix. There is neither pain nor fever, and the surrounding parts are healthy.

This may be taken as the ideal form of ulcer, and may conveniently be used as a type with which to compare the ulcers seen at the bedside, so that we may determine how far, and in what particulars, these differ from the type; and that we may in addition recognise the conditions which have to be counteracted before they assume the characters of the typical healing sore.

For purposes of contrast we may look at the characters of an ulcer in which bacterial infection has taken place. Suppose our skin-grafting wound become infected with virulent pyogenic bacteria, the effused blood and serum undergo septic changes and are converted into pus. No attempt at the formation of granulation tissue is made, and the base of the ulcer becomes red and irritable, is bathed in thin yellow or grumous pus, and probably tissue necrosis takes place here and there and small sloughs form.

The discharge is profuse, thin, acrid, and offensive, and consists of pus, broken-down blood-clot and sloughs. The edges are inflamed, irregular and ragged, showing no sign of growing epithelium,—on the contrary, the sore may be actually increasing in area by the breaking-down of the tissues at the margins. The surrounding parts are in a state of inflammation—hot, red, swollen, and œdematous; and there is pain and tenderness both in the sore itself and in the parts around.

Classification of Ulcers.—The nomenclature of ulcers is at present much involved and gives rise to great confusion, chiefly for the reason that no one basis of classification has been adopted. Some ulcers are named according to the causes at work in producing or maintaining them—for example, the traumatic, the septic, and the varicose ulcer; some from the constitutional dyscrasia present, as the tuberculous, the syphilitic, the gouty, and the diabetic ulcer; and others according to the condition in which they happen to be when seen by the surgeon, such as the weak, the inflamed, the callous, and the healing ulcer.

So long as we retain many of these names it will be impossible to find a single basis for classification; and yet many of the terms are so convenient, so descriptive, and so generally understood that it is undesirable to abolish them. We must therefore remain content with a clinical arrangement of ulcers—it cannot be called a classification,—considering any given ulcer from two points of view: first, its *cause*, and second, its *present condition*. This method of studying ulcers has the practical advantage that it furnishes us with the main indications for treatment as well as for diagnosis,—the cause must be removed, and the condition so modified as to convert the ulcer into an aseptic healing sore.

A. **Arrangement of Ulcers according to their Cause.**—It has already been indicated that the main cause of ulceration is the action of pyogenic bacteria, and that in addition there is usually some other factor present which determines the special characters of the ulcer and the clinical variety to which it belongs.

Ulcers due to Traumatism.—Traumatism in the form of a *crush* or *bruise* is a frequent cause of ulcer formation, acting either by directly destroying the skin, or by so diminishing its vitality that it is rendered a suitable soil for bacteria. If these gain access, in the course of a few days the damaged area becomes of a greyish colour, large blebs form over it, and the skin dies and separates, leaving a raw surface with feeble granulations and portions of sloughy tissue adherent to it.

Burns and Scalds act in a similar way. Exposure to the Röntgen rays has been followed by a severe form of sloughing ulceration.

The *Pressure* of improperly-padded splints or other appliances may so far interfere with the local circulation of the part pressed upon that an ulcer is formed. This is most liable to occur in patients who suffer from some nerve lesion—such, for example, as infantile paralysis, or injury of the spinal cord or nerve-trunks. Splint-pressure sores are situated over bony prominences, such as the malleoli, the condyles of the femur or humerus, the head of the fibula, the dorsum of the foot, or the base of the fifth metatarsal bone. On removing the splint the skin of the part pressed upon is found to be of a red or pink colour, with a pale grey patch in the centre, which eventually sloughs and leaves an ulcer.

Similar ulcers are occasionally produced artificially by malingerers and hysterical subjects.

Pressure also plays a part in the production of *bed-sores.*

Ulcers due to Imperfect Circulation.—Imperfect circulation is an important causal factor in ulceration, especially when it is the *venous return* which is defective. This is best illustrated in the so-called *leg ulcer*, which occurs almost invariably on the front and inner aspects of the lower third of the leg. At this point the anastomosis between the superficial and deep veins of the leg is less free than elsewhere, so that the extra stress thrown upon the surface veins interferes with the nutrition of the skin (Hilton). The importance of this factor in the causation of such ulcers is evidenced by the fact that all methods of treatment are unavailing unless the patient be confined to bed and the limb elevated. In a considerable number of cases, but by no means in all, this form of ulcer is associated with the presence of varicose veins, and in such cases it is spoken

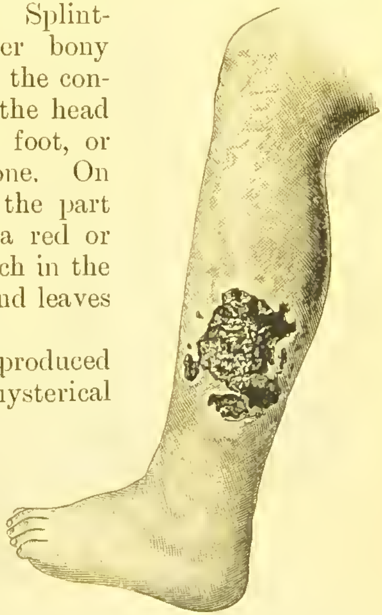

FIG. 12.—Chronic Ulcer of Leg associated with Varicose Veins.

of as the *varicose ulcer* (Fig. 12). Any slight injury or irritation of the devitalised area is liable to permit of septic infection and lead to ulceration. Dermatitis and eczema are common in association with varicose veins, and the scratching or rubbing of the part is very liable to break the surface and permit of infection. Such ulcers may also originate in the bursting of a small peri-phlebitic abscess.

Varicose veins in immediate relation to the base of a large chronic ulcer usually become thrombosed, and in time are reduced to fibrous cords, and therefore in such cases hæmorrhage is not a common complication. In smaller and more superficial ulcers, however, the destructive process is liable to implicate the wall of the vessel before the occurrence of thrombosis, and to lead to profuse and often dangerous bleeding.

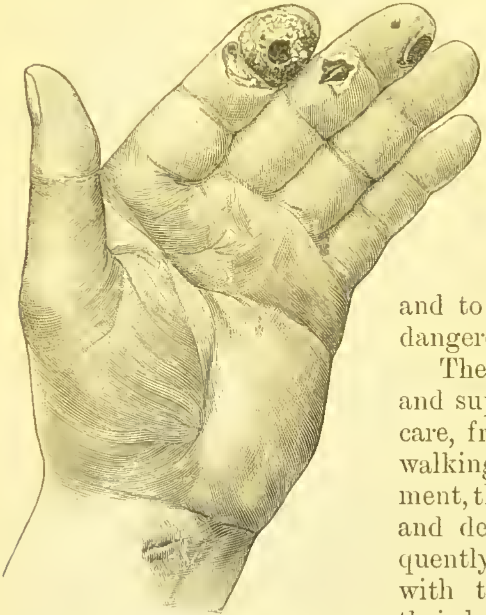

FIG. 13.—Trophic Ulcers of Fingers following Division of Median Nerve above Wrist.

These ulcers are at first small and superficial, but from want of care, from continued standing or walking, or from injudicious treatment, they gradually become larger and deeper. They are not infrequently multiple, and this, together with their depth, may lead to their being mistaken for syphilitic ulcers. The base of the ulcer is covered with imperfectly-formed, soft, œdematous granulations, which give off a thin sero-purulent discharge. The edges show signs of slight inflammation, and no evidence of healing. The parts around are usually pigmented and slightly œdematous, and as a rule there is little pain. This variety of ulcer is particularly prone to pass into the condition known as callous.

In *anæmic* patients, especially young girls, ulcers are occasionally met with which have many of the clinical characters of those associated with imperfect venous return. They are very slow to heal, and tend to pass into the condition known as weak.

Ulcers due to Interference with Nerve-supply.—Any interference with the nerve-supply of the superficial tissues predisposes to ulceration. For example, *trophic* ulcers are liable to occur in injuries or diseases of the spinal cord, in cerebral paralysis, in limbs weakened by infantile paralysis, in ascending or peripheral neuritis, or after injuries of nerve-trunks (Fig. 13). It is believed by some that the common chronic ulcer of the leg is dependent upon altered trophic innervation, as well as upon changes in the venous circulation.

The *acute bed-sore* is a very rapidly progressing form of ulceration, often amounting to gangrene, of portions of skin exposed to pressure after having had their trophic nerve-supply interfered with.

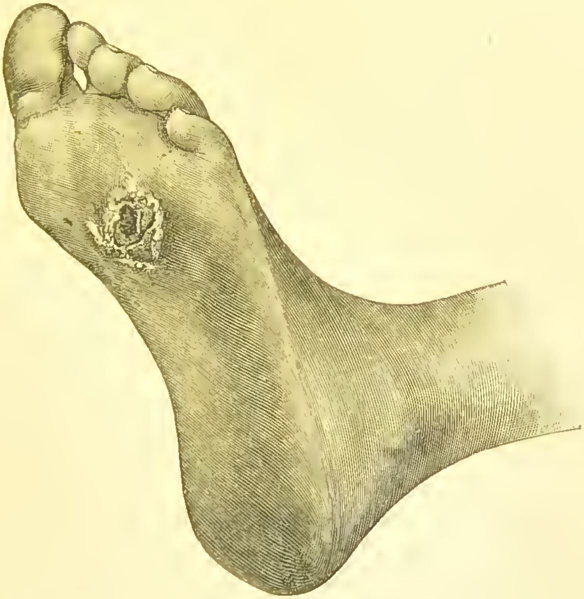

FIG. 14.—Perforating Ulcer on the Foot of a woman æt. 62, who suffered from Diabetes.

The ordinary *pressure bed-sore*, although not necessarily associated with defective nerve-supply, may be so.

The *perforating ulcer of the foot* is a peculiar type of sore which occurs in association with the different forms of peripheral neuritis, and with various lesions of the brain and spinal cord, such as general paralysis, locomotor ataxia, or syringo-myelia. It also occurs in patients suffering from glycosuria (Fig. 14). Perforating ulcer is met with most frequently under the head of the metatarsal bone of the great toe. A callosity forms, and suppuration occurs under it, the pus escaping through a small hole in the centre. So long as the patient continues to go about, the process slowly and gradually spreads deeper and deeper, till eventually the bone or joint is reached, and becomes implicated in the destructive process—hence the term "perforating ulcer." The flexor tendons are sometimes destroyed, the toe being dorsiflexed by the unopposed extensors. The depth of the track being so disproportionate to its superficial area, the condition closely simulates a tuberculous sinus for which it is liable to be mistaken. The raw surface is absolutely insensitive, so that the probe can be freely employed without the patient even being aware of it or suffering the least discomfort—a significant fact in diagnosis. The cavity is filled with effete and decomposing epidermis which has a most offensive odour. The chronic and intractable character of these ulcers is due to interference with the trophic nerve-supply to the parts, and to the fact that the epithelium of the skin grows in and lines the track leading down to the deepest part of the ulcer and so prevents closure. While they are commonest on the sole of the foot and other parts subjected to pressure, perforating ulcers are met with on the sides and dorsum of the foot and toes, on the hands, and on other parts where no pressure has been exerted. It is to be borne in mind that ulcers occur in the foot under callosities independently of any nerve lesion. Although very slow to heal, they do not show the same tendency to burrow and persist as the perforating ulcer does.

Ulcers due to Constitutional Causes.—Various constitutional dyscrasiæ favour the production of ulcers by diminishing the power of resistance in the tissues. In some cases the tissue weakness results from the action of a specific pathogenic virus, as in tuberculosis, syphilis, or leprosy; while in others, so far as we at present know, it depends on impurities or deficiencies of the blood, as in diabetes, Bright's disease, scurvy, and gout.

The *tuberculous ulcer* so often seen in the neck, in the vicinity of joints, or over the ribs and sternum, usually results from the bursting through the skin of a tuberculous abscess. The base is soft, pale, and covered with feeble granulations and grey shreddy sloughs. The edges are of a dull blue or purple colour, and gradually thin out towards their free margins, and in addition are characteristically undermined, so that a probe can be passed for some distance between the floor of the ulcer and the thinned-out edges. Thin, devitalised tags of skin often stretch from side to side of the ulcer. The outline is irregular; small perforations often occur through the skin, and a thin, watery discharge, containing grey shreds of tuberculous debris, escapes.

The *syphilitic ulcer* is usually formed by the breaking down of a cutaneous or subcutaneous gumma. It is at first covered by a tough greyish slough, compared to "wash leather," which slowly separates and leaves a more or less circular, deep, punched-out gap which shows a few feeble unhealthy granulations and small sloughs on its floor. The edges are raised and indurated; and the discharge is thick, glairy, and peculiarly offensive. The parts around the ulcer are congested and of a dark-brown colour. There are usually several such ulcers together, and as they tend to heal at one part while they spread at another, the affected area assumes a sinuous or serpiginous outline. Syphilitic ulcers may be met with in any part of the body, but are most frequent in the upper part of the leg (Fig. 15), especially around the knee-joint in women, and over the ribs and sternum. On healing they usually leave a depressed cicatrix.

The *scorbutic ulcer* occurs in patients suffering from scurvy, and is characterised chiefly by its marked tendency to bleed.

In *gouty* patients small ulcers which are exceedingly irritable and painful are liable to occur.

Other ulcers related to special morbid diatheses need not be specified here.

Ulcers associated with Malignant Disease.—Certain malignant tumours, such as scirrhus of the breast, epithelioma of the tongue or lip, and some sarcomata, frequently invade the skin or mucous membrane, and appear on the surface as open, vascular sores. These are sometimes spoken of as malignant ulcers, but as they are essentially different in their nature from all other forms of ulcers, and call for totally different treatment, it is best to consider them along with the tumours with which they are associated. Rodent ulcer,

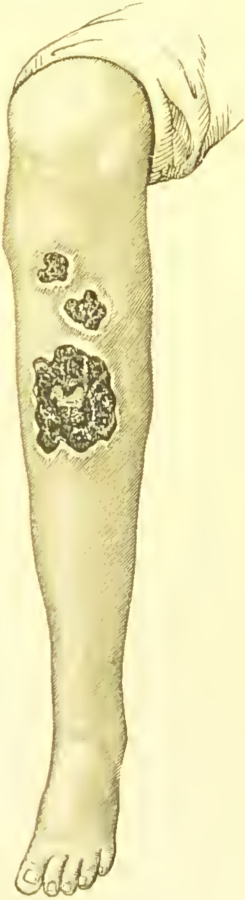
Fig. 15.—Ulcers of Leg in a patient suffering from Inherited Syphilis.

which is one form of cancer of the skin, will be discussed with tumours of the skin. It will be pointed out later that certain inflammatory ulcers are liable to become the seat of malignant disease.

B. **Arrangement of Ulcers according to their Condition.** —Having arrived at an opinion as to the cause of a given ulcer, and placed it in one or other of the preceding groups, the next question to ask one's self is, "In what condition do I find it at the present moment?"

For practical purposes it may be said that any ulcer is in one of three states—healing, stationary, or spreading; although it is not uncommon to find healing going on at one part while the ulcer is extending at another.

The Healing Ulcer.—The process of healing in an ulcer has already been studied, and we have learned that it takes place by the formation of granulation tissue, which becomes converted into fibrous tissue, and is covered over by epithelium growing in from the adjacent skin edges.

Those that are *stationary*—that is, neither healing nor spreading—may be in one of several conditions.

The Weak Condition.—Any ulcer may get into a weak state from receiving a blood-supply which is defective either in quantity or in quality. The granulations on the base are small and smooth, and of a pale yellow or grey colour. The discharge is small in amount, and consists only of thin serum and a few pus cells. This dries on the edges and forms scabs which interfere with the growth of epithelium.

Should the part become œdematous either from general causes, such as heart, kidney, or liver disease, or from local causes, such as varicose veins, the granulations share in the œdema, and a large quantity of thin, serous discharge escapes, but no healing takes place.

The excessive use of moist dressings leads to a third variety of weak ulcer—namely, one in which the granulations become large, soft, pale, and flabby, projecting beyond the level of the skin and overlapping the edges, which become pale and sodden and cease to grow. This constitutes what is popularly known as "proud flesh." The same condition may arise when induration around prevents contraction of the sore.

The Callous Condition.—This condition is usually met with in ulcers on the lower third of the leg, and is often associated with the presence of varicose veins. The want of healing is mainly due to impeded venous return and to the œdematous and indurated condition of the parts around. This induration of the surrounding tissues results from coagulation and partial organisation of the inflammatory effusion, and prevents the necessary contraction of the sore. The base of a callous ulcer lies at some distance below the level of the swollen, thickened, and white edges, and presents a glazed appearance, such granulations as are present being unhealthy and irregular. The characteristic discharge is a thin, serous fluid, mixed with pus, and having a foul odour. Unless when inflamed, pain is not a prominent feature. The sufferers from this variety of ulcer are chiefly met with in hospital practice.

The prolonged hyperæmia of the tissues in relation to a callous ulcer of the leg often leads to peculiar changes in the underlying bones. The periosteum is abnormally thick and vascular, the superficial layers of the bone become injected and porous, and the bones, as a whole, are thickened. In the macerated bone "the surface is covered with irregular, stalactite-like processes or foliaceous masses, which, to a certain extent, follow the line of attachment of the interosseus membrane and of the intermuscular septa" (Cathcart) (Fig. 16). When the whole thickness of the soft tissues is destroyed by the ulcerative process, the area of bone which comes to form the base of the ulcer projects as a flat, porous node. In course of time the ulcer eats its way into the bone, and produces depressions or erosions on its surface. These changes have often been mistaken for primary disease in the bone.

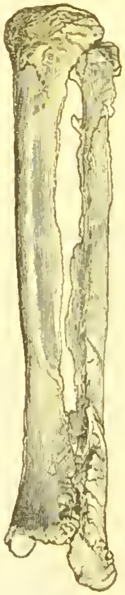

FIG. 16.—Tibia and Fibula, illustrating the Changes associated with Chronic Ulcer of the Leg.

(Museum of Royal College of Surgeons, Edinburgh.)

The *irritable condition* is met with in ulcers which occur, as a rule, just above the external malleolus in women of neurotic temperament. They are small in size and have prominent granulations, and by the aid of a probe points of excessive tenderness may be discovered. These, Hilton believed, correspond to exposed nerve filaments.

Ulcers which are spreading may be met with in one of several conditions.

The Inflamed Condition.—Any ulcer may become acutely inflamed from the access of fresh organisms, aided by mechanical irritation from trauma, ill-fitting splints or bandages, or want of rest, or from chemical irritants such as strong antiseptics. The best clinical example of an inflamed ulcer is the venereal soft sore. The base of the ulcer becomes red and angry-looking, the granulations disappear, and a copious discharge of thin, yellow pus, mixed with blood, escapes. Sloughs of granulation tissue or of connective tissue may form. The edges become red, ragged, and everted, and the ulcer increases in size by spreading into the inflamed and œdematous surrounding tissues. Such ulcers are frequently multiple. Pain is a constant symptom, and is often severe, and there is usually some constitutional disturbance.

The *phagedænic condition* is the result of an ulcer being infected with specially virulent bacteria. It often occurs in syphilitic ulcers, and leads to a very rapid and destructive infiltration of the surrounding tissues, with the formation of sloughs and much pus. It is also met with in the throat in some cases of scarlet fever, and may give rise to fatal hæmorrhage by ulcerating into large blood-vessels. All the signs of inflammation, both local and constitutional, are present to a marked degree.

Treatment of Ulcers.—The prompt and patient treatment of ulcers is a matter of great practical importance. An ulcer is not only an immediate cause of suffering to the patient, crippling and incapacitating him for his work, but is a distinct and constant menace to his health: the prolonged discharge reduces his strength; the open sore is a possible source of infection by the organisms of suppuration, erysipelas, or other specific diseases. Phlebitis, with formation of septic emboli, leading to pyæmia, is liable to occur; and in old persons it is not uncommon for ulcers of long standing to become the seat of cancer. In addition, the offensive odour of many ulcers renders the patient a source of annoyance and discomfort to others.

Principles of Treatment applicable to all Ulcers.—The primary object of treatment in any ulcer is to bring it into the condition of a healing sore. When this has been effected nature will do the rest, provided extraneous sources of irritation be excluded.

Rest is an essential condition to the repair of all ulcers, and is best secured by confining the patient to bed. Elevation of the part to facilitate the venous return is also most important. The limb should be placed on pillows, or the foot of the bed raised upon blocks, so that the ulcer lies at a higher level

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than the heart. These measures at the same time encourage the absorption of inflammatory exudation around the ulcer, and this may be aided by *massage*. In certain varieties of ulcers associated with altered trophic innervation, nerve-stretching has been employed with advantage.

The use of elastic pressure or of strapping also accelerates the removal of exudation around ulcers, and so facilitates the contraction of the sore.

The removal of all sources of irritation, such as unsuitable dressings, ill-fitting splints, irritating applications, and, above all, septic organisms and their products, is imperative.

A septic ulcer must be thoroughly disinfected by washing not only the open surface, but also the skin for some distance around it, with an antiseptic lotion, such, for example, as lysol (1 in 100), to remove grease, and then with Lister's strong solution or carbolic lotion (1 in 20). Hair-covered parts should be shaved. The raw surface should then be swabbed over with undiluted carbolic acid or sprayed with peroxide of hydrogen. If the granulations are œdematous and unhealthy, they may be removed with a sharp spoon. An antiseptic dressing is then applied, and changed daily till the wound assumes a healthy appearance.

As the patient's health is below par, good nourishing food, tonics, and general hygienic treatment are indicated.

By paying attention to these general rules, and by employing certain special measures in different varieties of ulcers, the conditions of a healing sore will be obtained.

Management of a Healing Sore.—Perhaps the best dressing to apply to a healing sore is a layer of Lister's perforated oiled-silk protective. This is made to cover the raw surface and the skin for about a quarter of an inch beyond the margins of the sore. Over this three or four thicknesses of sterilised gauze, wrung out of boracic lotion or sterilised water, are applied, and covered by a pad of antiseptic absorbent wool. A splint is applied to ensure rest, and the part is elevated to avoid congestion.

The dressing may be renewed every two or three days, and care must be taken to avoid any rough handling of the sore. Any discharge which lies on the surface should be removed by a gentle stream of lotion rather than by wiping. The area around the sore should be carefully cleansed before the fresh dressing is applied.

In some cases healing goes on more rapidly under a dressing of weak boracic ointment (one quarter the strength of the pharmacopœial preparation).

Dusting powders and poultice dressings are best avoided in the treatment of healing sores.

Treatment of Special Varieties of Ulcers.—Before beginning to treat a given ulcer two questions have to be answered—first, What are the causal conditions present? and second, In what condition do I find the ulcer?—in other words, In what particulars does it differ from a healthy healing sore?

If the cause be a local one, it must be removed; if a constitutional one, means must be taken to counteract it. This done, the condition of the ulcer must be so modified as to bring it into the state of a healing sore, after which it will be managed on the lines already laid down.

Treatment in relation to the Cause of the Ulcer.—*Traumatic Group.* — The *prophylaxis* of these ulcers consists in rigidly excluding bacteria, by cleansing crushed or bruised parts with antiseptic lotions, and applying sterilised dressings and properly-adjusted splints. These measures will often prevent a grossly-injured portion of skin sloughing, and will ensure its aseptieity should it do so. In the event of the skin giving way, the same form of dressing should be continued till the slough has separated and a healthy granulating surface is formed. The protective dressing appropriate to a healing sore is then substituted. *Pressure sores* are treated on the same lines.

The treatment of *burns and scalds* will be described later.

In the case of *ulcers due to interference with the venous return*, the primary indication is to elevate the limb to facilitate the free flow of the blood in the veins. Should varicose veins be present, the question of operative treatment must be considered.

When an *imperfect nerve-supply* is the main factor underlying ulcer formation, prophylaxis is the chief consideration. In patients suffering from spinal injuries or diseases, cerebral paralysis, or affections of the peripheral nerves, all sources of irritation, such as ill-fitting splints, tight bandages, moist applications, and hot bottles, should be avoided. Any part liable to pressure, from the position of the patient or otherwise, must be carefully protected by pads of wool, air-cushions, or water-bags, and must be kept absolutely dry. The skin should be hardened by daily applications of methylated spirit.

Should an ulcer form in spite of these precautions, the mildest and least irritant antiseptics must be employed for bathing and dressing it, and as far as possible all dressings should be dry.

The *perforating ulcer* of the foot calls for special treatment. To avoid pressure on the sole of the foot, the patient must be confined to bed. As the main local obstacle to healing is the down-growth of epithelium along the sides of the ulcer, this must be removed by the knife or sharp spoon. The base also should be excised, and any bone which may have become involved should be gouged away so as to leave a healthy and vascular surface. The cavity thus formed is stuffed with iodoform gauze and encouraged to heal from the bottom. After the ulcer is healed, the patient should wear in his boot a thick felt sole with a hole cut out opposite the situation of the cicatrix. When a joint has been opened into, the difficulty of thoroughly getting rid of all unhealthy and infected granulations is so great that amputation may be advisable; but it is to be remembered that the ulcer sometimes recurs in the stump when pressure is put upon it.

Stretching of the plantar nerves has been successful in hastening the healing of perforating ulcers (Chipault).

The treatment of any nervous disease or glycosuria which may coexist is, of course, indicated. The ulcer which forms in relation to callosities on the sole of the foot is treated by paring away all the thickened skin after softening it with soda fomentations, removing the unhealthy granulations, and applying stimulating dressings.

Treatment of Ulcers due to Constitutional Causes.—When ulcers are associated with such constitutional diseases as diabetes, Bright's disease, scurvy, or gout, these must be treated on general principles.

Tuberculous and syphilitic patients must also receive the appropriate medicinal and dietetic treatment for their general conditions.

The *tuberculous ulcer* calls for special local treatment. By means of knife, scissors, or sharp spoon, all foci of tuberculous disease, whether in the skin or in the deeper parts, must be freely removed, so as to leave a healthy surface from which granulations may spring up. Should the raw surface left be extensive and likely to result in an unsightly scar, much benefit may result from skin-grafting.

In some cases the area involved is so extensive that the surgeon may hesitate to excise it bodily. The alternative is to clip or scrape away all grossly-diseased tissue and granulations, to slit up all sinuses, and then to purify everything with undiluted carbolic acid. Iodoform is held in high esteem as an agent which counteracts the tubercle bacillus and its products.

In many cases marked benefit has followed treatment by the X-rays.

The healing of such sores is often slow and tedious, and experience shows that frequent changes in the dressings employed are often beneficial.

The Syphilitic Ulcer.—No ulcerative process responds so readily to medicinal treatment as the syphilitic ulcer does to full doses of iodide of potassium and mercury, and the local application of black wash. When the ulceration has lasted for a long time, however, and is widespread and deep, the duration of treatment is materially shortened by a thorough scraping with the sharp spoon.

Treatment in relation to the Condition of the Ulcer.—*Ulcers in a Weak Condition.*—If the weak condition of the ulcer be due to anæmia or kidney disease, these affections must first be treated. Locally, the imperfect granulations should be scraped away, and some stimulating agent, such as sulphate of zinc in the form of red lotion, applied to the raw surface till healthy granulations form.

When the condition has resulted from the prolonged use of moist dressings, these must be stopped, the redundant granulations clipped away with scissors, the surface rubbed with silver nitrate or sulphate of copper (blue-stone), and dry dressings applied.

When the ulcer has assumed the characters of a healing sore, Thiersch grafts may be applied to hasten cicatrisation.

Ulcers in a callous condition call for treatment in three directions—(1) The venous return must be facilitated by elevation of the limb and massage. (2) The induration of the surrounding parts must be got rid of before contraction of the sore is possible. For this purpose the free application of blisters, as first recommended by Syme, leaves little to be desired. Liquor epispasticus painted over the parts, or a large fly-blister (emplastrum cantharidis) applied all round the ulcer, speedily disperses the inflammatory products which cause the induration. Pressure applied by imbricated strips of adhesive plaster or by elastic bandages is less satisfactory and more troublesome than Syme's method. (3) The septic element in the ulcer must be eliminated. When the ulcer is very foul, relays of charcoal poultices (three parts of linseed meal to one of charcoal), maintained for thirty-six to forty-eight hours, are useful as a preliminary step. The base of the ulcer and the thickened edges should then be freely scraped with a sharp spoon, and the resulting raw surface sponged over with undiluted carbolic acid, after which an antiseptic dressing is applied, and changed daily till healthy granulations appear. When these are slow to form, the sore may be stimulated by a dressing of boracic lint wrung out of red lotion and covered with a layer of gutta-percha tissue.

So soon as the ulcer assumes the characters of a healing sore, it should be covered with Thiersch skin-grafts, which form a much better cicatrix than is left when the ulcer is allowed to heal without such aid.

A more radical and very successful method of treatment consists in excising the whole ulcer and grafting the raw surface left.

Ambulatory Treatment.—When the circumstances of the patient forbid his lying up in bed the healing of the ulcer will be much delayed. He should be instructed to take every possible opportunity of placing the limb in an elevated position; and must constantly wear a firm bandage of *elastic webbing.* This webbing is porous and admits of evaporation of the skin and wound secretions—an advantage it has over Martin's rubber bandage. The bandage should extend from the toes to well above the knee, and should always be applied while the patient is in the recumbent position with the leg elevated, preferably before getting out of bed in the morning. Additional support is given to the veins if the bandage is applied as a figure-of-eight, after the method suggested by Heron-Watson.

Unna's bandage—a bandage stiffened with gelatine—is useful, but somewhat inconvenient for the class of patients who usually suffer from this condition.

An *inflamed* ulcer is treated by rest, elevation, and the application of moist antiseptic and soothing dressings. Ichthyol ointment spread on gauze and applied to the surrounding parts is very soothing.

The *phagedænic* ulcer is simply an aggravated form of the inflamed variety produced by some virulent organism or poison, and calls for more energetic treatment to arrest its spread, which is often rapid and destructive. The whole of the affected surface may be touched with the actual cautery at a white heat, or the surface may be painted with pure carbolic acid and a dressing of iodoform gauze applied.

The *irritable* state of an ulcer may depend upon constitutional neurotic tendencies, uterine irregularities, or upon a gouty diathesis, and in treatment these must be counteracted. Locally the most satisfactory treatment is complete excision and subsequent skin-grafting. Failing this, the use of the sharp spoon, silver nitrate, or pure carbolic acid may be tried.

Skin-Grafting.

The term skin-grafting is applied to certain procedures in which portions of epithelium or skin are applied to raw or granulating surfaces with a view to promoting the rapid formation of a cicatrix which is at once strong and pliable, and which does not subsequently tend to undergo contraction.

The grafts may be taken from the patient himself,—on the whole the most satisfactory source,—from another person, or from one of the lower animals.

The procedure is applicable to all forms of ulcers when in a healthy, healing condition, especially those resulting from burns, severe crushes, or septic processes involving wide destruction of skin. It may also be employed to cover in the raw surfaces left after the excision of new growths implicating the skin, or of patches of lupus. In rectifying such defects as extroversion of the bladder, ectropion of the eyelids, destruction of the cheek or nose, and in other plastic operations also, skin-grafting is often of value.

It is of primary importance that the surface on which the grafts are placed should be aseptic and have a good vascular supply. The surrounding tissues also must be free of inflammation, œdema, or induration.

The best results are obtained when the grafts are placed on a fresh raw surface. A granulating surface is less satisfactory, because of the difficulty of ensuring its asepticity, and on account of the tendency of a cicatrix formed by granulation tissue to undergo contraction.

Preparation of the Surface.—For two or three days the ulcer and its surroundings should be thoroughly purified, and it is often advantageous to paint the surface with pure carbolic acid daily during this period.

In old-standing ulcers of the leg it is best to excise the whole ulcer, including its edges and about a quarter to half an inch of the surrounding tissue, as well as the underlying fibrous tissue. In extensive ulcers resulting from recent burns, it is only necessary to scrape away the superficial layer of the granulations, the young fibrous tissue underneath being conserved, as it is sufficiently vascular to nourish the grafts placed over it. There is no advantage in preserving any young epithelium which may have formed round the ulcer, as this is very liable to break down after the grafts have united, leaving a raw ring round the newly-formed cicatrix. Oozing can be stopped by pads of sterilised gauze saturated with peroxide of hydrogen (10 volumes strength), and after the bleeding has ceased the excess of peroxide solution is washed away by a copious yet gentle stream of tepid saline solution. In some cases pressure with a pad of sterilised gauze is sufficient to arrest the oozing, a layer of oiled silk having been placed next the wound to prevent the gauze adhering and starting the bleeding afresh when the gauze is removed.

The part from which the grafts are taken should be disinfected as for any other operation.

Methods of Grafting.—The various grafting procedures which have been suggested and practised fall into three groups: epithelium-sowing; epithelium-grafting; and skin-grafting proper.

By *epithelium sowing* is meant the scattering over a granulating sore of free epithelial cells obtained by scraping the surface of some other part of the body. A certain proportion of the cells thus planted live and grow and so help the healing process. They at the same time seem to promote the growth of the marginal epithelium. The resulting cicatrix, however, is thin and unstable, and is so liable to break down that this method is not to be recommended.

Several different procedures, all of which involve the transplantation of tangible portions of epithelium, are included under the term *epithelium-grafting.* Of these the methods of Reverdin, Lusk, and Thiersch are the most useful.

In *Reverdin's* method a portion of the patient's skin is raised with the point of a needle, and a piece about the size of a split pea removed with a razor or a pair of scissors curved on the flat. The graft, which consists of the epidermis and the superficial layers of the rete mucosum, is then cut into fragments not bigger than a pin-head, and these are planted over the surface. As each of these fragments has only a potential growth of about half an inch in diameter, it is advisable to place them so that the edges of the adjacent epithelial islets which form will touch one another, and to plant them near the edge of the ulcer, in order that the grafted epithelium may blend with that of the margin and so consolidate the cicatrix. Unless this is done granulations grow up between the islets and often destroy them. The prepuce removed from a healthy child by circumcision may be used for Reverdin grafting.

The dressing consists of imbricated pieces of oiled-silk protective covered with pads of aseptic gauze and absorbent wool, the part being immobilised by a suitable splint. The dressing is changed in four or five days. Many of the grafts disappear temporarily, but reappear in the course of a few days as thin bluish-white patches which gradually increase in size and thickness. Great care is necessary to prevent the cicatrix from breaking down again. The application of lanoline or weak boracic ointment (a quarter the pharmacopœial strength) prevents the young epithelium from cracking, and keeps it soft and pliable.

Lusk's method consists in transplanting to the ulcerated surface the epidermis from a blister, raised intentionally by blistering fluid, or taken from an accidental burn.

Thiersch's Method.—For all practical purposes this is the procedure which yields the most satisfactory results and which is most generally applicable. It consists in transplanting strips of epidermis, shaved from the surface of the skin, the razor passing through the tips of the papillæ. The grafts are most conveniently obtained from the inner aspect of the thigh or upper arm, or from the front of the forearm, the skin in these regions being soft, pliable, and comparatively free from hairs. They are cut with a sharp, hollow-ground razor, or Thiersch's skin-grafting knife, the blade of which is moistened with warm saline solution. The skin is stretched and kept flat and perfectly steady. To ensure uniform strips being cut the razor must be kept parallel with the surface, and used with a short, rapid sawing movement. With a little practice grafts six or eight inches long by one or two inches broad can readily be cut.

The strips of epithelium thus obtained are directly transferred to the raw surface prepared for them, for which they should be made to form a complete carpet, slightly overlapping the edges of the sore and of one another.

Firm pressure is then made with a pad of gauze over the grafts to express blood and air-bubbles, and to ensure accurate apposition. Some difference of opinion exists regarding the best dressing. It would appear that when the grafts are applied to a fresh raw surface, and when there is no reason to anticipate any discharge, a dry, aseptic gauze dressing is most appropriate, or the same gauze smeared with sterilised vaseline. When the grafts are applied to a granulating surface, however, and when there may be doubt as to its perfect asepticity, perforated protective should be applied.

The surface from which the grafts have been taken is covered with a dry gauze dressing, or with a dressing of picric acid such as is used for superficial burns.

It is often difficult to decide when the dressing should be changed. In cases where a dry dressing has been employed it may be left in position for from seven to ten days, by which time the grafts have united. It may then be replaced by a dressing of weak boracic ointment or lanoline. When a protective dressing is used it must be changed every third or fourth day until the grafts become fixed, after which an ointment dressing is substituted. In all cases the utmost gentleness and care are necessary to avoid disturbance of the adhesions between the grafts and the ulcer. After grafting leg ulcers, prolonged rest in the recumbent position is imperative, to obviate the tendency of the cicatrix to break down when the limb is allowed to hang. The limb should not be used for walking within two or three months of being grafted.

The new skin is at first insensitive and is fixed to the underlying tissue, but in course of time new nerve fibres grow into it and sensation is restored, and the development of elastic tissue in the deeper part of the cicatrix renders it pliable and movable.

Skin-grafting proper consists in transplanting portions of the whole thickness of the true skin, excluding the subcutaneous fat. When the grafts are taken from the human subject they should be cut oval or spindle-shaped, to facilitate the stitching of the edges of the resulting wound; and it is to be borne in mind that when separated from the body these portions of skin contract to about two-thirds of their original size. This shrinkage must be allowed for when it is desired to cover a raw surface with a single graft. These grafts take best on a fresh raw surface, and it is sometimes an advantage to stitch them in position, especially on the face. The primary dressing and the subsequent treatment are the same as in Thiersch grafting. When successful this method yields most satisfactory results, but the proportion of failures is greater than with Thiersch's method.

Skin-grafting from the Lower Animals.—The best results have been obtained by planting the whole thickness of the skin of young warm-blooded animals, such as puppies, kittens, or rabbits, on a fresh raw surface. The animal is killed with chloroform, the anterior abdominal wall and flanks are shaved, and the skin, after being dissected up free of fat, is cut into pieces about two inches by one, and placed on the surface to be covered in. The after treatment is the same as in Thiersch grafting. The hairs and skin glands are not reproduced.

Grafting of Mucous Membrane.—Successful attempts have been made to cover over defects in various mucous membranes, such as the conjunctiva, the cheek, and the urethra, by grafts of mucous membrane taken from man or from the lower animals. The technique is similar to that employed in skin-grafting.

CHAPTER VII.

GANGRENE.

Definition—Clinical types: *Dry*, *Moist*—Clinical varieties—Gangrene primarily due to interference with the circulation: *Physico-chemical group; Embolic gangrene; Senile gangrene, atheroma; Diabetic gangrene; Gangrene from angeio-sclerosis; Gangrene from ergot; Raynaud's disease; Gangrene after acute fevers*—Gangrene primarily due to bacterial infection: *Acute traumatic gangrene; Malignant œdema; Cancrum oris; Phagedæna*—Bed-sores.

THE term gangrene is used to indicate the process by which a portion of tissue dies *en masse*, as distinguished from the molecular or cellular death which constitutes ulceration. The dead portion is known as a *slough*.

Gangrene may occur in any tissue of the body, and portions of limbs, of intestine, of lung, penis, or even of brain tissue, may die *en masse* and be thrown off as sloughs.

In this chapter we shall confine our attention to the process as it affects the limbs and superficial parts of the body, leaving gangrene of the viscera to be described in regional surgery.

CLINICAL TYPES OF GANGRENE.

Two distinct types of gangrene are met with clinically, which, from their most obvious point of difference, are known as *dry* and *moist gangrene* respectively.

We shall have to study each of these types in detail; but, speaking generally, it may be said that dry gangrene is essentially due to a simple *interference with the blood-supply* of a part; while an essential factor in the production of moist gangrene is *bacterial infection*.

Several clinical varieties of each type are met with, but before describing these we shall first study the fundamental distinctions between the two types.

Dry Gangrene or Mummification is a comparatively slow form of local death resulting, as a rule, from a diminution in the arterial blood-supply of the affected parts, due to such causes as the sudden blocking of the main vessel of supply by a thrombus, or the gradual diminution of the lumen of the arteries by atheroma. The fluids in the tissues are lost by evaporation, and the part becomes dry and shrivelled.

As the skin is usually intact, bacterial infection does not take place, or if it does, the want of moisture in the part renders it an unsuitable soil, and the organisms do not readily find a footing. Thus inflammatory reaction is absent, and any spread of the process which may take place is influenced by the anatomical distribution of the blocked arteries, and is arrested as soon as it reaches an area rich in anastomotic vessels. The throwing off of the dead portion is brought about by the formation of what is known as a *line of demarcation*. The irritation resulting from the contact of the dead with the still-living tissue causes hyperæmia with dilatation of the blood-vessels, and leucocyte infiltration on the proximal side of the junction. Granulations soon form on the living tissue, and by slowly eating into the dead portion produce a furrow, which gradually deepens until the complete separation of the slough is effected. As the death of skin and subcutaneous tissues extends higher than that of muscles and bone, the stump left after spontaneous separation is conical, the end of the bone projecting beyond the soft parts.

Clinical Features.—The part undergoing mortification becomes colder than normal, the temperature falling to that of the surrounding atmosphere. In many instances, but not in all, the onset of the process is accompanied by severe neuralgic pains in the part, probably due to anæmia of the nerves, to neuritis, or to the irritation of the exposed axis cylinders by the dead and dying tissues around them. This pain soon ceases and gives place to a complete loss of sensation. The dead part becomes dry, horny, shrivelled, and semi-transparent—at first of a dark-brown, but finally of a black colour, from the dissemination of blood pigment throughout the tissues. There is no putrefaction, and therefore no disagreeable odour.

The condition being non-inflammatory, there is not necessarily any constitutional disturbance. Dry gangrene, therefore, does not in itself involve any risk to the patient's life, beyond furnishing a means of entrance for bacteria through the line of demarcation.

Moist Gangrene is an acute process, the dead part retaining its normal fluids, and so affording a favourable soil for the development of putrefactive or pyogenic bacteria. The action of the organisms, their toxins, and the inflammatory exudates on the adjacent tissues lead to a rapid and wide spread of the process. The nuclei of the tissue cells lose their normal structure, the protoplasm becomes disintegrated and the whole tissue softened. Leucin, tyrosin, margaric acid and other products of decomposition form in the part. The formation of a sulphide of iron by decomposition of the blood pigment gives to the tissues a greenish-black colour. The putrefactive gases evolved cause the tissues to become emphysematous and crepitant. The skin becomes moist and macerated, and bullæ, containing dark-coloured fluid or gases, form under the epidermis. There is always an offensive putrid odour. Under certain conditions the dead part may undergo changes resembling more closely those of ordinary post-mortem decomposition. Owing to its nature the process seldom spontaneously arrests itself, but usually continues to spread, and proves fatal from the absorption of toxins into the circulation.

The *clinical features* vary in the different varieties of moist gangrene, but in all we have the local results of bacterial action more or less marked; and the usual constitutional disturbance associated with such processes—the temperature raised, the pulse feeble, rapid, and compressible, and the gastro-intestinal functions deranged. There is usually a marked degree of leucocytosis. The prognosis in moist gangrene is always grave in the extreme.

From what has been said it will be gathered that in dry gangrene there is no urgent call for operation to save the patient's life, the primary indication being to prevent the access of bacteria to the dead part, and so to permit of the natural formation of a line of demarcation. In moist gangrene, on the contrary, the organisms having already obtained a footing, immediate operation, as a rule, offers the only hope of saving the patient.

Clinical Varieties of Gangrene.

As has already been pointed out, the factor which plays the most important *rôle* in determining whether a given case of gangrene belongs to the moist or the dry type is the presence or absence of *bacterial infection.* When organisms are present moist or inflammatory gangrene occurs; when they are excluded the gangrene is of the dry or non-inflammatory type.

The different forms which gangrene assumes clinically are so varied that it is difficult to devise a simple classification. For practical purposes, however, they may be divided into two great classes: I. Those in which the gangrene is essentially due to *interference with the circulation;* and II. Those in which it is essentially due to *bacterial infection.*

Gangrene essentially due to Interference with the Circulation.—This group includes the various forms of local tissue necrosis in which micro-organisms do not play the most important part in producing death. Their subsequent introduction is an accident, albeit one of such importance that it changes the whole aspect of affairs and converts a dry form of gangrene into one of the moist type. Moreover, the low state of vitality of the tissues, and the extreme difficulty of securing and maintaining asepsis make it a sequel of great frequency.

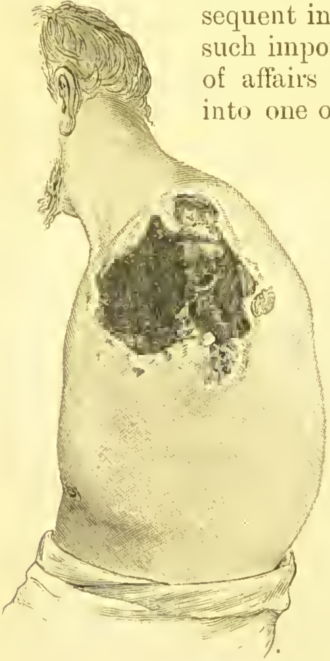

FIG. 17.—Dry Gangrene of Skin after Amputation at Shoulder-joint for Railway Injury.

Gangrene from Physico-chemical Causes.—When a localised portion of tissue—for example, a piece of skin—is so severely crushed or bruised that its blood-vessels are occluded and its structure destroyed, it immediately dies, and, if not infected with bacteria, dries up and forms a shrivelled brown slough, which is slowly separated by the growth of granulation tissue beneath and around it (Fig. 17).

Fingers, toes, or even considerable portions of limbs may in the same way be suddenly destroyed by severe trauma and undergo mummification. If organisms gain access, typical moist gangrene may ensue, or changes similar to those of ordinary post-mortem decomposition may take place.

Severe *burns* and *scalds* may be followed by the same results. So long as the parts are kept absolutely dry—as, for example, by the picric acid method of treatment—the grossly-damaged portions of tissue undergo dry gangrene; but when moist or oily dressings are applied and organisms gain access, moist gangrene follows.

Frost-bite.—It is difficult to draw the line between the third degree of chilblain and the milder forms of true frost-bite.

The difference is merely one of degree. Frost-bite affects chiefly the toes and fingers,—especially the great toe and the little finger,—the ears, and the nose. In this country it is seldom seen except in members of the tramp class, who, in addition to being exposed to cold by sleeping in the open air, are ill-fed and generally debilitated. The condition usually manifests itself after the parts, having been subjected to extreme cold, are brought into warm surroundings. The first symptom of frost-bite is numbness in the part. This is followed by a sense of weight, tingling, and finally by complete loss of sensation. The part attacked becomes white and bleached-looking, feels icy cold, and is insensitive to touch. Either immediately, or, it may be, not for several days, it becomes discoloured and swollen, and finally it contracts and shrivels. The dead portion is cast off, as in other forms of dry gangrene, by the formation of a line of demarcation. When recovery ensues, its onset is indicated by the white parts assuming a livid red hue and becoming the seat of an acute burning sensation.

Prophylaxis.—The first essential in the prophylaxis of frost-bite is to avoid the too sudden application of heat. The patient should be placed in a cold room, and the part rubbed with snow or put in a cold bath, and have light friction applied to it. As the circulation is restored the general surroundings and the local applications are gradually made warmer. Elevation of the part, wrapping it in cotton wool, and removal to a warmer room are then permissible, and stimulants and warm drinks may be given with caution.

Strong *chemical agents*, such as caustic potash, nitric or sulphuric acid, may also induce local tissue necrosis. The resulting sloughs are very slow to separate, and leave deep punched-out cavities which are slow of healing.

Carbolic acid, even in comparatively weak solution, is liable to induce dry gangrene when applied as a moist dressing to the fingers of certain individuals, especially women and children (Fig. 18). Thrombi form in the blood-vessels of the part, which at first is pale and soft, but later becomes dark and leathery. On account of the anæsthetic action of carbolic acid the onset of the process is painless, and the patient does not realise his danger. A line of demarcation soon forms, but the dead part separates very slowly.

Gangrene from Mechanical Constriction of the Vessels of the part.—The application of a bandage or plaster of Paris case too tightly, or of a tourniquet for too long a time, has been known to lead to death of the part beyond; but such cases are rare, as are also those due to the pressure of a fractured bone or of a tumour on a large artery or vein. When gangrene occurs from such causes it tends to be of the moist type. Much commoner is it to meet with localised areas of sloughing due to the excessive pressure of splints over bony prominences, such as the external malleolus, the internal condyle of the humerus or femur, or over the dorsum of the foot. This is especially liable to occur when the nutrition of the skin is depressed by any interference with its nerve-supply, such as follows injuries to the spine or peripheral nerves, diseases of the brain, or infantile paralysis. On removing the splint the part pressed upon is found to be of a pale yellow or grey colour, and is surrounded by a ring of hyperæmic or congested skin. If purified and protected from sepsis the slough behaves in the same way as that resulting from direct mechanical violence.

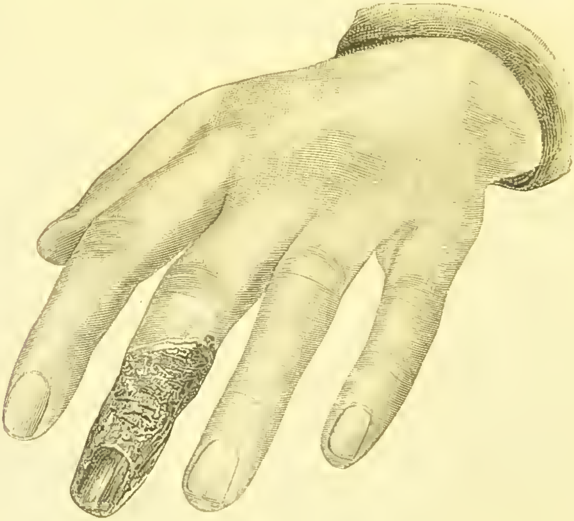

FIG. 18.—Carbolic Gangrene. Girl æt. 22. Carbolic compress (1 in 60) applied over night. Finger gangrenous in the morning.

Closely allied to this is the *bed-sore* in which sloughs of the skin and soft parts often form, and expose the bone. These will be described at the end of this chapter.

Treatment.—The first indication in the treatment of the above varieties of gangrene is the exclusion of bacteria by thorough purification of the damaged tissue and its surroundings, and the application of dry, non-irritating antiseptic dressings.

When these measures are successful dry gangrene ensues. The raw surface left after the separation of a slough of the skin may be allowed to heal by granulation, or may be covered by Thiersch skin-grafts. In the case of fingers or limbs it is not necessary to wait until spontaneous separation takes place, as this is often a very slow and tedious process. When a well-marked line of demarcation has formed, amputation may be performed just sufficiently far above it to enable suitable flaps to be made.

The ends of stumps left after spontaneous separation of the gangrenous portion require to be trimmed, sufficient bone being removed to permit of the soft parts coming together.

When infection causes moist gangrene, amputation must be performed at a higher level.

Embolic Gangrene.—When the main artery of a part is *suddenly* occluded, whether by the impaction of an embolus or the formation of a thrombus in its lumen, or by the application of a ligature around it, unless the collateral circulation is sufficiently free to maintain the vitality of the tissues, gangrene results.

There is sudden pain at the site of impaction of the embolus, and the pulses beyond are lost. The limb becomes cold, numb, insensitive, and powerless. It is often pale at first—hence the term "white gangrene" sometimes applied to the early appearances, which closely resemble those presented by the limb of a corpse.

If the part is aseptic it becomes shrivelled, and presents the ordinary features of dry gangrene. It is very liable, however, especially in the lower extremity, and where the veins also are obstructed, to become infected and to assume the characters of the moist type.

The *abdominal aorta* may become suddenly occluded by an embolus, the obstruction extending into the iliacs and femorals, and inducing symmetrical gangrene of both extremities as high as Poupart's ligament. Occlusion of the *common femoral artery* often results in gangrene of the limb as high as the middle or upper third of the thigh, especially if the vein be obstructed at the same time. When the *superficial femoral or popliteal artery* is obstructed, the veins remaining pervious, the anastomosis through the profunda is sufficient to maintain the vascular supply, and gangrene does not necessarily follow. The rupture of a popliteal aneurysm, however, by compressing the vein and the articular vessels, usually determines gangrene. When an embolus becomes impacted at the *bifurcation of the popliteal* the gangrene which ensues usually spreads well up the leg.

When the *axillary artery* is the seat of embolic impaction and gangrene ensues, the process usually reaches the middle of the upper arm. Gangrene following blocking of the *brachial* at its bifurcation usually extends as far as the lower third of the forearm.

Treatment.—The general treatment of embolic gangrene is the same as that for the senile form, which will be described in the next section. When amputation is indicated it must be performed sufficiently high to ensure a free vascular supply to the flaps.

Senile Gangrene.—Senile gangrene is the commonest example of local death produced by a *gradual* diminution in the quantity of arterial blood passing through the parts, as a result of atheroma or other chronic disease of the vessels leading to diminution of their calibre. It is the most typical example of the dry type of gangrene. As the term indicates, it occurs in old persons; but the patient's age is to be reckoned by the condition of his arteries rather than by the number of his years (Fig. 19). Thus the vessels of a comparatively young man who has suffered from syphilis and been addicted to alcohol are more liable to atheromatous degeneration leading to this form of gangrene than are those of a much older man who has lived a regular and abstemious life. This form of gangrene is much more common in men than in women. It must clearly be understood that any form of gangrene may occur in old persons, the term senile being here restricted to that variety which results from atheroma.

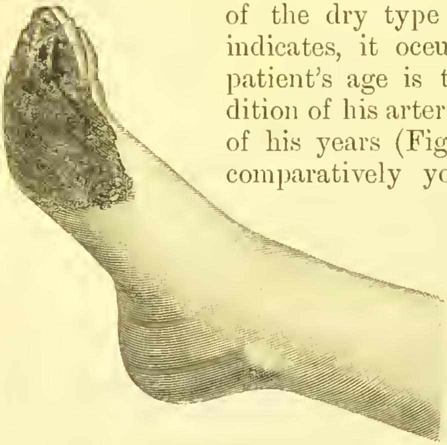

FIG. 19.—Senile Gangrene in a man, æt. 48, whose Arteries were extremely atheromatous.

Clinical Features.—The commonest seat of the disease is in the toes, especially the great toe, whence it spreads up the foot to the heel, or even to the leg. Although not necessarily traumatic in origin, there is often a history of some slight injury preceding its onset. The vitality of the tissues is so low that the balance between life and death may be turned by the most trivial injury, such as a cut while paring a toe-nail or a corn, a blister caused by an ill-fitting shoe or the contact of a hot-bottle. In some cases the actual gangrene is determined by thrombosis of the popliteal or tibial arteries, which are already narrowed by atheroma.

It is common to find that the patient has complained of extraordinarily cold feet, with tingling and loss of feeling, or a peculiar sensation as if walking on cotton wool, for a long time before the onset of definite signs of gangrene.

The first evidence of the death of the part varies in different cases. Sometimes a dark-blue spot appears on the inner side of the great toe and gradually increases in size; or a blister containing blood-stained fluid may form. In other cases a small sore surrounded by a congested areola forms in relation to the nail and refuses to heal. Such "sore-toes" in old persons are always to be looked upon with suspicion and treated with the greatest care. There is often severe, deep-seated pain of a neuralgic character, with cramps in the limb, and these may persist long after a line of demarcation has formed, or even after the slough has separated. The dying part loses sensibility to touch and becomes cold and shrivelled.

All the physical appearances and clinical symptoms associated with dry gangrene supervene, and the dead portion is thrown off by the formation of a line of demarcation. This is a very slow process, and is always attended with the risk of septic infection taking place. Should this occur, the temperature rises and other evidences of septic absorption appear.

Prophylaxis.—The toes and feet of old people, the condition of whose circulation predisposes them to gangrene, should be specially protected from slight injuries such as may be received while paring nails, cutting corns, or wearing ill-fitting boots. They should also be warned of the risk of exposure to cold, the use of hot-bottles, and of placing the feet near a strong fire.

Treatment.—When there is evidence that gangrene has begun, the first indication is to prevent septic infection by thoroughly purifying the part with an efficient antiseptic, and after careful drying to wrap it in a thick layer of absorbent and antiseptic wool, retained in place by a loosely-applied bandage. A slight degree of elevation of the limb is an advantage, but it must not be sufficient to diminish the amount of blood entering the part. Hot-bottles are to be used with the utmost caution. As absolute dryness is essential, all ointments or other oily or greasy dressings are to be avoided, as they tend to prevent evaporation from the skin surface. Opium should be given freely to alleviate pain. Excessive stimulation is to be avoided, and the patient should be carefully dieted.

Some surgeons advocate the expectant method of treatment, waiting for a line of demarcation to form and allowing the dead part to be spontaneously separated. This takes place so slowly, however, that the majority prefer to amputate early.

In this connection it is worthy of note that there are certain points at which gangrene naturally tends to become arrested—namely, at the highly-vascular areas in the neighbourhood of joints. Thus gangrene of the great toe often stops when it reaches the metatarso-phalangeal joint; or if it trespass this limit it may be arrested either at the tarso-metatarsal or at the ankle joint. If these be passed it usually spreads up the leg to just below the knee before signs of arrestment appear. Further, it is seen from pathological specimens that the spread is greater on the dorsal than on the plantar aspect, and that the death of skin and subcutaneous tissues extends higher than that of bone and muscle.

These facts furnish us with valuable indications as to the seat and method of amputation. Experience has proved that in senile gangrene of the lower extremity reliable and satisfactory results are only to be obtained by amputating in the region of the knee, care being taken to perform the operation so as to leave the prepatellar anastomosis intact by retaining the patella in the anterior flap. The operation recommended is disarticulation at the knee by means of a circular incision carried round the limb, about three inches below the tubercle of the tibia, the joint being fully extended (A. G. Miller). Gritti's supra-condylar amputation is also suitable. Hæmorrhage is easily controlled by digital pressure, and the use of a tourniquet should be dispensed with, as the constriction of the limb is liable to interfere with the vitality of the flaps.

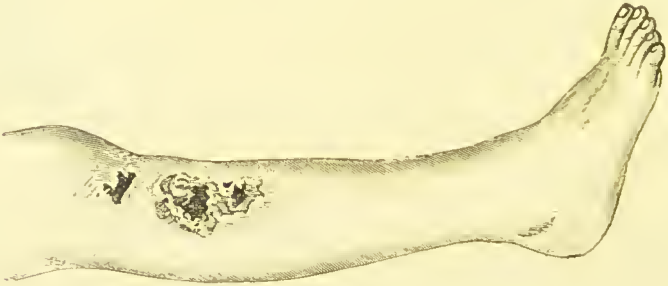

FIG. 20.—Diabetic Gangrene of Skin.

When the tibial vessels can be felt pulsating at the ankle it may be justifiable, if the patient urgently desires it, to amputate lower than the knee; but in the great majority of cases gangrene recurs in the stump and necessitates a second operation.

That amputation for senile gangrene performed between the ankle and the knee seldom succeeds is explained by the fact that the vascular obstruction is usually in the upper part of the posterior tibial artery, and the operation is therefore performed through tissues with an inadequate blood-supply.

In spite of the feeble condition of many of these patients, it is found that the operation is borne remarkably well, provided it is done early and before the patient is worn out by pain and want of sleep.

Diabetic Gangrene.—This form of gangrene occurs in subjects suffering from diabetes, and shows a marked tendency to assume the moist type (Figs. 20 and 21). It may begin as an ordinary dry senile gangrene, but on account of the excessively low vitality of the tissues, bacterial infection is prone to occur and to change the type of the disease. In other cases, however, it has peculiar characters of its own from the onset. The abnormal chemical substances circulating in the blood produce endarteritis, and the innervation of the parts is deficient; and these factors, together with the general low vitality of the tissues, render the access of bacteria specially liable to produce a degree of inflammatory reaction which ends in gangrene. The process spreads rapidly, causing great destruction of skin. There is usually a peculiarly offensive odour about the patient, which differs from that of other forms of moist gangrene. Death usually occurs from toxaemia, diabetic coma, or exhaustion.

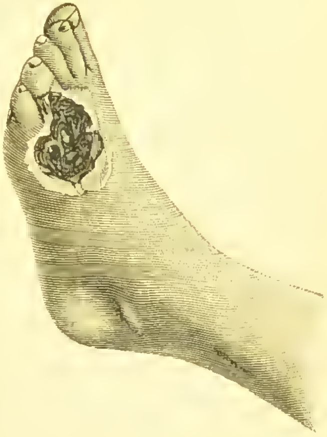

FIG. 21.—Diabetic Gangrene. Glycosuria unsuspected till Gangrene developed.

The *surgical treatment* depends on whether the gangrene is of the dry or moist type. The prognosis both as to life and as to recurrence of the disease in the stump after amputation must be guarded. The rules for amputation are the same as those governing the treatment of senile gangrene.

A form of gangrene is occasionally met with in robust young persons, even in children, due to a marked degree of *angiosclerosis*, with narrowing and thrombosis of the main arteries as well as of the smaller veins. It usually occurs in the feet, is exceedingly painful, and runs a slow, tedious course, usually calling for amputation.

Gangrene from Ergot.—Gangrene may occur from interference with blood-supply, the result of tetanic contraction of the minute vessels, such as results in ill-nourished persons who eat large quantities of coarse rye bread contaminated with the *claviceps purpurea* and containing the ergot of rye. The process, which attacks the toes, fingers, ears, or nose, is preceded by formication, numbness, and pains in the parts to be affected. Following on this, dry gangrene supervenes, and may spread to a considerable extent.

In this country it is usually met with in sailors off foreign ships, whose dietary largely consists of rye bread. Trivial injuries may be the starting-point, the anæsthesia produced by the ergotin preventing the patient taking notice of them. Alcoholism is a potent predisposing cause.

As it is impossible to predict how far the process will spread, it is advisable to wait for the formation of a line of demarcation before operating on these cases, and then to amputate immediately above the disease.

Raynaud's Disease, or Symmetrical Gangrene, is supposed to be due to spasm of the arterioles, resulting from peripheral neuritis. It occurs oftenest in neurotic females, between the ages of eighteen and thirty, who are the subjects of uterine disorders, anæmia, or chlorosis. Cold may be a predisposing factor, as the disease is commonest during the winter months. The digits of both hands or the toes of both feet are simultaneously attacked, and the disease seldom spreads beyond the phalanges or deeper than the skin.

The first evidence is that the fingers become cold, white, insensitive to touch and pain. These attacks of *local syncope* recur at varying intervals for months or even years. They last for a few minutes or even for some hours, and as they pass off the parts become hyperæmic and painful.

A more advanced stage of the disease is known as *local asphyxia.* The circulation through the fingers becomes exceedingly sluggish, and the parts assume a dull livid hue. There is swelling and burning or shooting pain. This may pass off in a few days, or may increase in severity, with the formation of bullæ, and end in dry gangrene. As a rule the slough which forms is comparatively small and superficial, but it may take some months to separate. The condition tends to recur in winter.

The *treatment* consists in attending to the general condition of the patient, remedying any nervous or uterine disorder which may be present, and keeping the parts warm by wrapping them in cotton wool. When gangrene occurs it is treated on the same lines as other forms of dry gangrene, but if amputation is called for it is only with a view to removing the dead part.

Gangrene occurring after Acute Fevers.—A variety of dry gangrene is sometimes met with in patients recovering from typhus, typhoid, or other fevers. It is due to endarteritis, thrombosis, or embolism, and occurs in peripheral parts, such as the toes, fingers, nose, or ears.

Bacterial Varieties of Gangrene.

Gangrene associated with the action of bacteria is of the moist type, and tends to spread rapidly and to end fatally.

Acute Traumatic Gangrene usually follows very early on such severe injuries as result from railway, machinery, or street accidents, where, in addition to the extensive laceration and bruising of tissues, including vessels and nerves, there is gross dirt ground into the wounds. On the other hand, it may follow very trivial injuries, such as a pin-prick or a scratch. Some virulent pathogenic organism is introduced, and flourishes in the devitalised tissues, producing a degree of acute inflammatory reaction, with extensive stasis and interference with the venous return. The highly poisonous toxins not only lead to serious constitutional disturbances, but by their local irritant action add to the venous stasis, and so determine a rapidly-spreading gangrenous process.

Clinical Features.—Often within a few hours of the accident there is great pain in the wound, and the whole part rapidly becomes swollen, œdematous, and tense. The skin is at first glazed, and perhaps paler than normal, but soon assumes a dull red or purplish hue, and bullæ form on the surface. Putrefactive gases may be evolved in the tissues, and their presence is indicated by emphysematous crackling when the part is handled. The spread of the disease is so rapid that its progress is quite visible from hour to hour, and may be traced by the occurrence of red lines along the course of the lymphatics of the limb.

In the most acute cases the death of the affected part takes place so rapidly that the local changes indicative of gangrene have not time to occur, and the fact that the part is dead may be overlooked.

Rigors may occur, but the temperature is not necessarily raised—indeed it is sometimes subnormal. The pulse is small, feeble, rapid, and irregular. Unless promptly treated by amputation, death usually follows within thirty-six or forty-eight hours. Even early operation does not always avert the fatal issue, because the quantity of toxin absorbed and its extreme virulence are often more than even a robust subject can outlive.

Prophylaxis.—Strenuous efforts must be made to purify thoroughly all such wounds as are contaminated by earth, street dust, stable refuse, or other forms of gross dirt. The scissors should be freely used to remove badly bruised or torn tissue, and no attempt should be made to close the wound by stitches. Rather should it be kept open with drainage-tubes or iodoform gauze or worsted inserted into its corners and crevices to ensure free drainage. As the organisms associated with this condition are mostly anaërobic, the use of peroxide of hydrogen is indicated.

Treatment.—For acute gangrene no treatment short of amputation is of any avail, and the sooner this is done the greater is the hope of saving the patient. The limb must be amputated well beyond the gangrenous area, through a part where there is good reason to believe that the main artery is unobstructed, and where the tissues are neither bruised, lacerated, nor œdematous. Thorough antiseptic preparation of the region selected, and stringent precautions to avoid discharge from the already gangrenous area reaching the operation wound, are of the utmost importance. An assistant or nurse, who is to take no other part in the operation, is told off to carry out this preliminary purification; to wrap the part to be removed in carbolised towels; and to hold the limb during the operation.

When the disease has spread so high that amputation above it is impossible, the dead part may be removed, and the surface of the stump sprayed with peroxide of hydrogen and then sponged over with pure carbolic acid. Anti-streptococcic serum has apparently proved of service in a certain number of cases. The patient must be freely stimulated after the operation, and fed with nutritious fluid food.

Malignant Œdema.—This form of acute spreading gangrene has been shown to be due to a specific organism, the *bacillus of malignant œdema*, which is found in garden soil, dung, and various putrefying animal substances. It is anaërobic, and occurs as long, thick rods with somewhat rounded ends and several laterally-placed flagella. Spores, having a very high power of resistance, form in the centre of the rod, and bulge out the sides so as to give the organism a spindle-shaped outline. Other pathogenic organisms are often present and aid it in its action.

Clinical Features.—The disease has been defined as "a spreading inflammatory œdema attended with emphysema, and ultimately followed by gangrene of the skin and subjacent parts." At the bedside it is difficult, if not impossible, to distinguish it from acute traumatic gangrene. Both follow on the same kinds of injury and run an exceedingly rapid course. In malignant œdema, however, the incidence of the disease is mainly on the superficial parts, which become livid, indurated, œdematous, and emphysematous, and soon die. Bullæ form on the skin, and the tissues have "a peculiar heavy but not putrid odour." The general constitutional effects of the disease are extremely severe, and death may ensue within a few hours.

The *treatment* is the same as that of acute traumatic gangrene, and the prognosis is even less hopeful.

In animals immunity can be produced by repeated injections of sterilised cultures or of the filtered serum of animals which have died of the disease.

Cancrum Oris or Noma.—This disease is believed to be due to a specific bacillus, which occurs in long delicate rods, and is chiefly found at the margin of the gangrenous area. It is most prone to attack unhealthy children from two to five years of age, especially during their convalescence from such diseases as measles, scarlet fever, or typhoid, but may attack adults when debilitated. It is most common in the mouth, but sometimes occurs on the vulva. In the mouth it begins as an ulcerative stomatitis, more especially affecting the gums or inner aspect of the cheek. The child lies prostrated, and from the open mouth foul-smelling saliva, streaked with blood, escapes. The face is of an ashy-grey colour, the lips dark-red and swollen. On the inner aspect of the cheek is a deeply-ulcerated surface, with sloughy shreds of dark-brown or black tissue covering its base. The edges are irregular, firm, and swollen, and the surrounding mucous membrane is inflamed and œdematous. In the course of a few hours a dark spot appears on the outer aspect of the cheek and rapidly increases in size. Towards the centre it is black, shading off through blue and grey into a dark-red inflamed area which extends over all the cheek. The tissue implicated is at first firm and indurated, but as it loses its vitality it becomes doughy and sodden. Finally a slough forms, perforating the cheek.

Meanwhile the process spreads inside the mouth, so that the gums, the floor of the mouth, or even the jaws become gangrenous and the teeth fall out. The constitutional disturbance is severe, the temperature raised, and the pulse feeble and rapid.

The extremely fœtid odour which pervades the room or even the house the patient occupies, is usually sufficient to suggest the diagnosis of cancrum oris. It must not be mistaken for the decomposition of sordes on the teeth and gums of a debilitated patient. It is most important to recognise the disease early, otherwise treatment is of no avail.

The *prognosis* is always grave in the extreme, although spontaneous recovery is not unknown. Septic pneumonia is a not infrequent cause of death.

Treatment.—The only treatment of any avail is the thorough removal under chloroform of all the sloughy tissue, with the surrounding zone in which the organisms are active. This is most efficiently accomplished by the knife or scissors, cutting until the tissue bleeds freely, after which the raw surface is painted with undiluted carbolic acid and dressed with iodoform gauze. It is often necessary to remove large pieces of bone when the necrotic process has implicated the jaws. The mouth must be constantly sprayed with peroxide of hydrogen, and washed out with a disinfectant and deodorant lotion, such as Condy's fluid. The patient's general condition calls for free stimulation.

The deformity resulting from these necessarily heroic measures is often not so great as might be expected, and can be further diminished by plastic operations.

Phagedæna, Hospital Gangrene, and Diphtheritic Gangrene.—Fortunately little need be said regarding these conditions. They are chiefly of historical interest as having constituted at one time the scourge of surgical wards, and as having been the first diseases to disappear after the introduction of antiseptic surgery.

A few days after the infliction of a wound, pain and swelling appeared. On the surface of the wound, which became dry and pale, a false membrane formed, and under this the tissues ulcerated and became gangrenous with great rapidity. The false membrane became thicker and softer as the process progressed; the skin, cellular tissue, and muscles rapidly sloughed; and not infrequently large vessels were opened into, and death resulted from hæmorrhage. High fever, diarrhœa, sleeplessness, and delirium preceded the almost invariably fatal issue.

Amputation was the only treatment which offered any prospect of recovery.

BED-SORES.

Bed-sores are most frequently met with in old and debilitated patients, or in those whose tissues are devitalised by acute fevers or by such chronic diseases as lead to venous stasis. Any interference with the nerve-supply of the skin, whether from injury or disease of the central nervous system or of the peripheral nerves, strongly predisposes to the formation of bed-sores. Prolonged and excessive pressure over a bony prominence, especially if the parts be moist with skin secretions, urine, or wound discharges, determines the formation of the sore. Excoriations, which may develop into true bed-sores, sometimes form where two skin surfaces remain constantly apposed, as in the region of the scrotum or labium, under pendulous mammæ, or between fingers or toes confined in a splint.

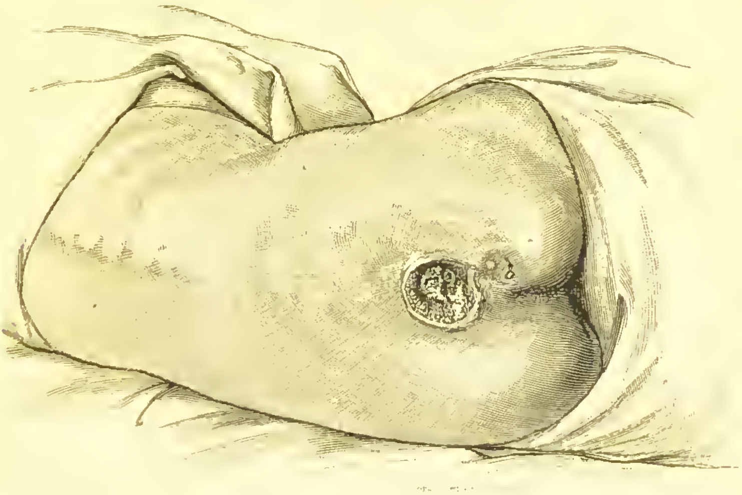

FIG. 22.—Bed-sore in a boy, æt. 16, who suffered from Fracture-dislocation of Spine in mid-dorsal region.

Clinical Features.—Two clinical varieties are met with—the acute and the chronic bed-sore.

The *acute* bed-sore (Fig. 22), usually occurs over the sacrum or buttock. It comes on very rapidly after spinal injuries and in the course of certain brain diseases. The part affected becomes red and congested, while the surrounding parts are œdematous and swollen. Blisters form, and the skin loses its vitality and dies.

In advanced cases of general paralysis of the insane, a peculiar form of acute bed-sore beginning as bullæ, and passing on to the formation of black, dry eschars, which slowly separate, frequently occurs on such parts as the inner side of the knee, the angle of the scapula, and the heel.

The *chronic* bed-sore (Fig. 23) begins as a dusky reddish purple patch, which gradually becomes darker till it is almost black. The parts around are œdematous, and vesicles may form. These burst and expose the papillæ of the skin, which are of a greenish hue. A tough greyish-black slough forms and is slowly separated. It is not uncommon for the gangrenous area to continue to spread both in width and in depth till it reaches the periosteum or bone. Bed-sores over the sacrum sometimes implicate the spinal canal and lead to septic spinal meningitis, which usually proves fatal.

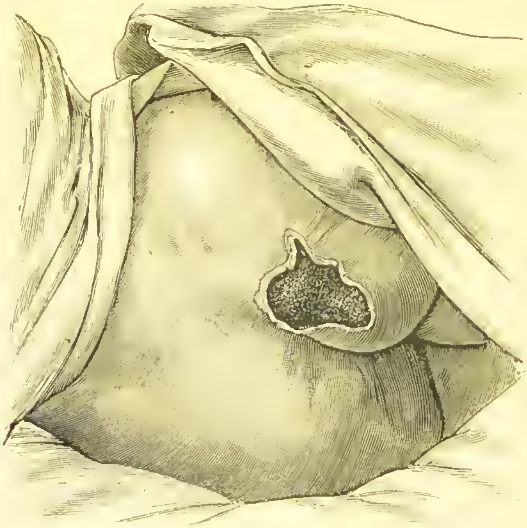

Fig. 23.—Pressure Bed-sore in an old woman with Fracture of Neck of Femur.

In old and debilitated patients the septic absorption taking place from a bed-sore often proves a serious complication of other surgical conditions. From this cause, for example, many old people succumb during the treatment of a fractured thigh.

The granulating surface left on the separation of the slough, under appropriate treatment tends to heal comparatively rapidly.

Prevention of Bed-sores.—The first essential to the prevention of bed-sores is the regular changing of the patient's position, so that no one part of the body will be pressed upon for any length of time at a stretch. Ring-pads of wool, air-cushions, or water-beds are necessary to remove pressure from prominent parts. Absolute dryness of the skin is all-important. At least once a day the sacrum, buttocks, shoulder-blades, heels, elbows, malleoli, or any other parts exposed to pressure must be sponged with soap and water, thoroughly dried, and then rubbed with methylated spirit, which is allowed to dry on the skin. Dusting the part with boracic acid powder not only keeps it dry, but prevents the development of bacteria in the skin secretions.

Treatment.—Once a bed-sore has formed, every effort must be made to prevent its spread. Mild antiseptic lotions are used to cleanse the broken surface, and dry absorbent dressings are applied and frequently changed. It is sometimes found necessary to employ moist or oily substances, such as boracic poultices, eucalyptus ointment, or balsam of Peru, to facilitate the separation of sloughs, or to promote the growth of granulations. In patients who are not extremely debilitated the slough may be excised, the raw surface scraped and then painted with undiluted carbolic acid.

Skin-grafting is sometimes useful in covering in the large raw surface left after separation or removal of sloughs.

CHAPTER VIII.

BACTERIAL AND OTHER WOUND INFECTIONS.

Erysipelas—Diphtheria—Tetanus—Hydrophobia—Anthrax—Glanders—Actinomycosis—Mycetoma—Delhi boil—Chigoe—Poisoning by insects—Snake bites.

ERYSIPELAS.

ERYSIPELAS is an acute spreading inflammation of skin or mucous membrane due to the action of a streptococcus. The organism was at one time believed to be specific as regards this disease, and was called by Fehleisen the *streptococcus erysipelatis*, but it is now generally accepted that it is the ordinary streptococcus pyogenes "of a certain degree of virulence," although the conditions which so modify it that it causes erysipelas are as yet not fully understood. Infection invariably takes place through an abrasion of the surface, although this may be so slight that it escapes observation even when sought for. With our improved methods of wound treatment, erysipelas very rarely attacks an operation wound. When it does occur it is usually in wounds about the face and mouth, where it is impossible to carry out antiseptic precautions perfectly. The streptococci are found most abundantly in the minute lymph spaces of the affected tissue, and in the serous blebs which sometimes form on the surface, but they never invade the blood-stream.

Microscopically, four zones are to be recognised from without inwards in a patch of erysipelatous inflammation. (1) Just beyond the reddened area is a zone in which active spread is taking place, all the lymphatic spaces being crowded with rapidly-multiplying streptococci; (2) the margin of the red area is in a state of acute inflammation, and the lymph spaces are crowded with leucocytes, many of which have streptococci in their interior; (3) in a zone internal to this the inflammatory signs are less marked, and all the free cocci have disappeared;

and (4) towards the centre of the patch the skin has regained its normal appearance, no permanent structural change having taken place.

Clinical Features.—After an incubation period, which varies from fifteen to sixty hours, the patient complains of headache, pains in the back and limbs, loss of appetite, nausea, and, very frequently, vomiting. He has a chill or slight rigor, initiating a rise of temperature to 103°, 104°, or 105° F., and a full bounding pulse of about 100 (Fig. 3). The tongue is foul, the breath heavy, and, as a rule, the bowels are constipated.

Around the seat of inoculation a diffuse red patch forms, varying in hue from a bright scarlet to a dull brick-red. The edges are slightly raised above the level of the surrounding skin, as may readily be recognised by gently stroking the part from the healthy towards the affected area. The skin is smooth, tense, glossy, and œdematous, with serous bullæ here and there over it. The local temperature is raised, and there is a burning sensation in the part, which is also tender to the touch, the most tender area being the actively-spreading zone which lies about half an inch beyond the red margin.

The disease tends to spread spasmodically and irregularly, and the direction and extent of its progress may be recognised by mapping out the peripheral zone of tenderness. Red streaks appear along the lines of the main superficial lymphatic vessels, and the deep lymphatics may sometimes be palpated as firm, tender cords. The neighbouring glands, also, are generally enlarged and tender.

The usual systemic symptoms associated with toxæmia are present—high temperature, gastro-intestinal disturbances, frequently albuminuria, and occasionally nocturnal delirium. Leucocytosis is usually present in well-marked cases, and increases while the erysipelas is spreading. The degree of leucocytosis furnishes a fairly accurate index of the severity of the condition.

The disease lasts for from two or three days to as many weeks, and relapses are frequent. Spontaneous resolution usually takes place, but the disease may prove fatal from absorption of toxins, involvement of the brain or meninges, or from septicæmia.

Clinical Varieties—*Facial erysipelas* is the commonest clinical variety, infection usually occurring through some slight abrasion in the region of the mouth or nose. From this point of origin the inflammation may spread all over the face and scalp as far back as the nape of the neck. It stops, however, at the chin, and never extends on to the front of the neck. There is great œdema of the face, the eyes becoming closed up, and the features unrecognisable. The inflammation may spread to the meninges, the intracranial venous sinuses, the eye, or the ear, and so add to the immediate risks, and lead to serious after-consequences. In some cases the erysipelas invades the mucous membrane of the mouth, and spreads to the fauces and larynx, setting up an œdema of the glottis which may prove fatal.

Erysipelas neonatorum occurs in the region of the umbilicus in young infants, and usually proves fatal. In puerperal women the infection may occur in the genital tract and give rise to a dangerous form of puerperal sepsis.

Complications.—*Diffuse suppurative cellulitis* is the most serious local complication, and results from a mixed infection with pyogenic bacteria. Small *localised superficial abscesses* frequently form during the convalescent stage. They are doubtless due to the action of skin bacteria which attack the tissues devitalised by the erysipelas. A persistent form of *œdema* sometimes remains after recurrent attacks of erysipelas, especially when they affect the face or the lower extremity. This condition is referred to again with elephantiasis.

Differential Diagnosis.—Any acute inflammatory condition implicating the skin may be mistaken for erysipelas, but a careful consideration of the clinical features will usually prevent serious error. In septic erythema, for example, the redness, instead of being sharply defined, gradually fades away towards the margins. Acute spreading gangrene and acute osteomyelitis have been mistaken for erysipelas.

Treatment.—The first indication in treatment is to arrest the spread of the process. By painting with linimentum iodi, a ring half an inch broad, about an inch in front of the peripheral tender zone—not the red margin—an artificial leucocytosis is produced, and the advancing streptococci are thereby arrested. Several coats of the iodine are applied, one after the other, and this is repeated daily for several days, even although the erysipelas has not overstepped the ring. Success depends upon using the liniment of iodine (the tincture is not strong enough), and in applying it well in front of the disease.

Scarification of the skin in front of the spreading margin acts in the same way, but is painful, and requires a general anæsthetic. Local applications of strong antiseptics, such as 1 in 20 carbolic lotion, or 1 in 1000 corrosive sublimate, have also been employed for the same purpose.

To prevent infection with additional pyogenic organisms, any wound, scratch, or blister which is present must be treated on antiseptic lines.

To allay the local pain perhaps the most useful applications are ichthyol ointment (1 in 6), thiol (in 20 to 40 per cent aqueous solution) painted on several times a day, or lead and opium fomentations.

The general treatment consists in attending to all the emunctories, in administering quinine in small—two-grain—doses every four hours, and in giving plenty of fluid nourishment. Perchloride of iron was at one time considered a specific in erysipelas, but its use has been largely given up, as it frequently deranges the stomach and produces constipation. It is worthy of note that the anti-streptococcic serum has proved of less value in the treatment of erysipelas than might have been expected in view of the fact that the disease is due to the action of a streptococcus.

Recent investigations seem to indicate that it is not necessary to isolate cases of erysipelas, provided the usual precautions against carrying infection from one patient to another are rigidly carried out.

DIPHTHERIA.

Diphtheria is an acute infectious disease due to the action of a specific bacterium, the *bacillus diphtheriæ* or *Klebs-Löffler bacillus.*

The commonest site of infection is the throat, where the effects are first local, and consist in the formation of a false membrane. This false membrane is composed of necrosed epithelium, fibrin, leucocytes, and red blood corpuscles. As the disease progresses, a general systemic toxin poisoning, associated with great muscular weakness, a tendency to syncope, and albuminuria, ensues. After the acute symptoms have passed off, various localised paralyses, affecting particularly the nerves of the palatal and orbital muscles, develop in from 15 to 20 per cent. of cases.

Etiology and Morbid Anatomy.—The diphtheria bacillus occurs in the form of short, slender rods, straight or slightly bent, and frequently having rounded or clubbed extremities. They form clusters of varying numbers, and may be found inside leucocytes. They do not form spores, but possess a high degree of resistance, even in the dry condition. The bacilli are found abundantly, and almost exclusively, in the more superficial parts of the false membrane. They rarely occur in the blood-vessels or tissues of the body. In the majority of cases the Klebs-Löffler bacillus is found associated with streptococci, less commonly with staphylococci, pneumococci, and other pathogenic bacteria, and these may give rise to various complications, such as cellulitis, suppuration in the glands of the neck, or septicæmia. The disease is usually transmitted from one patient to another, but it may be contracted from cats, fowls, or through the milk of infected cows. Cases have occurred in which the surgeon has carried the infection from one patient to another through neglect of ordinary antiseptic precautions.

The local cell necrosis which results in the formation of the false membrane is due to the action of the toxin. The congestion of internal organs, the cloudy swelling of the kidney, the hyaline degeneration of the heart muscle, and the parenchymatous degeneration of the myelin sheaths of the peripheral nerves are all due to the same cause. Leucocytosis is usually well marked.

Clinical Features.—The incubation period varies from two to seven days. On the first or second day of the disease redness and swelling of the mucous membrane of the pharynx, tonsils, and palate are well marked, and small, circular, greenish or grey patches of false membrane begin to appear. These rapidly increase in area and thickness, till they coalesce and form a complete covering to the parts. In the pharynx the false membrane is less adherent to the surface than it is in the air-passages. The lymphatic glands behind the angle of the jaw enlarge and become tender. There is pain on swallowing, and often ear-ache; and the patient speaks with a nasal accent. He becomes weak and anæmic, and loses his appetite. There is often albuminuria. The false membrane may become separated and cast off, after which the patient gradually recovers. Death may take place from asthenia or from sudden syncope during some slight exertion.

The disease may arise in the air-passages primarily, although, as a rule, it spreads thence from the pharynx. It first manifests itself by a short, dry, croupy cough and hoarseness of the voice. The difficulty in breathing usually first takes place suddenly during the night, and once it begins, it rapidly gets worse. Inspiration becomes noisy, sometimes stridulous or metallic or sibilant, and there is marked indrawing of the epigastrium and lower ribs. The voice becomes more rough, the cough more severe, and the patient very restless. The difficulty of breathing occurs in paroxysms, which gradually increase in frequency and severity until at length the exhausted patient becomes asphyxiated and dies. The duration of the disease varies from a few hours to four or five days.

Surgical Complications.—The diphtheritic process may spread to the nasal cavities, causing blocking of the nares, with a profuse ichorous discharge from the nostrils, and sometimes severe epistaxis. The inflammation may spread along the nasal duct to the conjunctiva. The middle ear also may become involved by spread along the Eustachian tube. Suppurative processes in the lymphatic glands or cellular tissue of the neck is usually a result of a superadded infection with streptococci.

The vulva, vagina, prepuce, glans penis, anus, and external auditory meatus may each be the seat of a diphtheritic inflammation. The process may also attack surgical wounds.

For a description of the pulmonary, renal, cardiac, and nervous complications, the reader is referred to books on medicine.

Diagnosis.—Diphtheria has to be diagnosed from suppurative tonsillitis and from croup. In true diphtheria, when the false membrane is removed, a raw bleeding surface is left. So much doubt exists as to the real nature of membranous croup and its relationship to true diphtheria, that when the diagnosis between the two is uncertain, the safest plan is to treat the case as one of diphtheria. The finding of the Klebs-Löffler bacillus is regarded by bacteriologists as the only conclusive evidence of the disease. The bacillus may be obtained by swabbing the throat with a piece of aseptic—not antiseptic—cotton wool or clean linen rag held in a pair of forceps, and rotated so as to entangle portions of the false membrane or exudate. The swab thus obtained is placed in a test-tube previously sterilised by having had some water boiled in it. The organism stains with a saturated watery solution of methylene blue. Cultures made on blood serum and kept for fourteen hours at the body temperature furnish reliable results. When a bacteriological examination is impossible, or when the clinical features do not coincide with the results obtained, the patient should always be treated on the assumption that he suffers from diphtheria. It is to be remembered that an inocuous organism, morphologically identical with the Klebs-Löffler bacillus, is frequently found in the nasal cavity and pharynx of healthy individuals.

Treatment.—An attempt may be made to destroy or to counteract the organisms by swabbing the throat with strong antiseptic solutions, such as 1 in 1000 corrosive sublimate or 1 in 30 carbolic acid, or by spraying with peroxide of hydrogen.

The antitoxic serum is our sheet anchor in the treatment of diphtheria, and recourse should be had to its use as early as possible. So great has been the lowering of the mortality by its use that a serious responsibility rests upon the practitioner who fails to give his patient the benefit of this method of treatment.

The initial dose should be a large one, certainly not less than 3000 units, and a further injection of 1500 units should be given in twelve hours if marked improvement does not take place. The earlier the injection, and the more concentrated the serum, the better are the results.

Within twenty-four hours of the injection the local symptoms usually begin to subside, and the membrane separates and is thrown off. At the same time the temperature falls, the pulse becomes slower, and the general condition of the patient improves. Beyond certain erythematous and urticarial rashes and transient joint pains, which sometimes occur, no inconvenience attends the use of the serum. It may therefore be given with benefit and safety even while the diagnosis is still in doubt, or as a prophylactic measure in the case of those exposed to the disease—for example, in public schools.

The general strength of the patient must be maintained by abundance of liquid food and stimulants.

Difficulty of swallowing nourishment may be met by the use of a stomach tube passed either through the mouth or nose. When this is impracticable, nutrient enemata are called for.

The introduction of the antitoxin treatment has greatly diminished the number of cases in which it becomes necessary to have recourse to intubation or tracheotomy on account of interference with respiration.

Intubation consists in introducing through the mouth into the larynx a tube which allows the patient to breathe freely during the period while the membrane is becoming separated and thrown off. This is best done with the apparatus of O'Dwyer; but when this instrument is not available, a simple gum-elastic catheter with a terminal opening (as suggested by Macewen and Annandale) is equally efficient.

In some cases the operation of tracheotomy is called for.

TETANUS.

Tetanus is a general disease resulting from the infection of a wound by a specific micro-organism, the *bacillus tetani*, and characterised by tonic contractions of one or more groups of muscles, with periodic exacerbations.

Etiology and Morbid Anatomy.—The tetanus bacillus is a slender rod-shaped organism. Each bacillus forms a single large spore, which is usually placed at one end and gives to the organism the shape of a drum-stick. The spores are highly resistant to chemical germicidal agents, conditions of dryness, and even survive boiling for five minutes.

The organism, which is a perfect anaërobe, is very widely distributed in nature, and is readily found in garden earth, dung heaps, and stable refuse. It can often be obtained also in the pus from the wound of infection in patients suffering from the disease, but it does not invade the body generally. Such wounds are usually small, unhealthy, and lined with necrotic tissue from which the special bacillus may be isolated, as well as other organisms—pyogenic or putrefactive—with which it is usually associated.

It is now believed that a broken surface, however small, is essential to the inoculation of the virus, and that no such thing as an "idiopathic" variety of tetanus exists.

It would appear, from experimental evidence, that the spores are the active agents in producing the disease, and that the presence of effused blood and some source of local irritation, such as a splinter of wood or other foreign body, favour their development. There is also reason to believe that the tetanus bacillus acts more certainly when introduced along with aërobic organisms, which, by using up the oxygen in the tissues, leave it a suitable environment..

On post-mortem examination of patients who have died of tetanus very few lesions are to be detected. The commonest are congestion of the central nervous system, notably the grey matter of the pons and medulla, and degenerative changes in the ganglion cells of the spinal cord.

Clinical Features.—The characteristic symptoms of tetanus do not, as a rule, appear earlier than the fourth or fifth day after the infliction of the wound, but the incubation period may extend to three weeks, and the wound may be quite healed before the disease declares itself. Usually, however, the wound is inflamed and suppurating, with ragged and sloughy edges. A slight feverish attack may mark the onset of the tetanic condition, or the patient may feel perfectly well until the spasms begin. If very careful observations be made, it may be found that the muscles in the immediate neighbourhood of the wound are the first to become contracted; but in the majority of instances the patient's first complaint is of pain and stiffness in the muscles of mastication (trismus), notably the masseter, so that he has difficulty in opening the mouth—hence the popular name "lock-jaw." The other facial muscles soon share in the rigidity, and the face assumes a fixed, mask-like aspect. The angles of the mouth may be retracted, producing a grinning expression known as the *risus sardonicus.*

The next muscles to become stiff and painful are those of the neck, especially the sterno-mastoid and trapezius. The patient is inclined to attribute the pain and stiffness to exposure to cold or rheumatism. At an early stage the diaphragm and the muscles of the anterior abdominal wall become contracted; later the muscles of the back and thorax are involved; and lastly those of the limbs. Although this is the typical order of involvement of the different groups of muscles, it is not always adhered to.

To this permanent tonic contraction of the muscles there are soon superadded clonic spasms. These spasms are at first slight and transient, with prolonged intervals between the attacks, but rapidly tend to become more frequent, more severe, and of longer duration, until eventually the patient simply passes out of one attack into another.

The distribution of the spasms varies in different cases, sometimes being confined to particular groups of muscles, such as those of the neck, back, abdominal walls, or limbs. In other cases all these groups are simultaneously involved.

When the muscles of the back become spasmodically contracted, the body is raised from the bed, sometimes to such an extent that the patient rests only on his heels and occiput—the position of *opisthotonos.* Lateral arching of the body from excessive action of the muscles on one side—*pleurosthotonos*—is not uncommon, the arching usually taking place towards the side on which the wound of infection exists. Less frequently the body is bent forward so that the knees and chin almost meet (*emprosthotonos*). Sometimes all the muscles simultaneously become rigid, so that the body assumes a statuesque attitude (*orthotonos*). When the thoracic muscles, including the diaphragm, are thrown into spasm, the patient experiences a distressing sensation as if he were gripped in a vice, and has extreme difficulty in getting breath. Between the attacks the limbs are kept rigidly extended. The clonic spasms may be so severe as to cause rupture of muscles or even to fracture a long bone.

As time goes on, the clonic exacerbations become more and more frequent, and the slightest external stimulus, such as the feeling of the pulse, a whisper in the room, a noise in the street, a draught of cold air, the effort to swallow, a question addressed to the patient or his attempt to answer, is sufficient to determine an attack. The movements are so forcible and so continuous that the nurse has great difficulty in keeping the bed-clothes on the patient, or even in keeping the patient in bed.

Gradually the patient becomes exhausted. The fits may cease some time before death, or, on the other hand, death may occur during a paroxysm from fixation of the diaphragm and arrest of respiration.

The general condition of the patient is pitiful in the extreme. He is fully conscious of the gravity of the disease, and his mind remains clear to the end. The suffering induced by the cramp-like spasms of the muscles keeps him in a constant state of fearful apprehension of the next seizure. Sleep is usually impossible until it results from utter exhaustion.

The temperature is moderately raised (100° to 102° F.), or it may remain normal throughout. Shortly before death very high temperatures (110° F.) have been recorded, and it has been observed that the thermometer sometimes continues to rise after death, and may reach as high as 112° F. or more.

The pulse corresponds with the febrile condition. It is accelerated during the spasms, and may become exceedingly rapid and feeble before death, probably from paralysis of the vagus. Sudden death from cardiac paralysis or from cardiac spasm is not uncommon.

The respiration is affected in so far as the spasms of the respiratory muscles produce dyspnœa, and a feeling of impending suffocation which adds to the horrors of the disease. Death from respiratory spasm sometimes takes place during a severe fit.

One of the most constant symptoms is a copious perspiration, the patient being literally bathed in sweat. The urine is diminished in quantity, but as a rule is normal in composition. As in other acute inflammatory conditions, albumin and blood may be present. Retention of urine may result from spasm of the urethral muscles. The appetite is lost, the tongue foul, and constipation most obstinate.

The *prognosis* varies in the different varieties of tetanus. The main factors are the duration of the incubation period; the rapidity with which different groups of muscles have become involved; the degree of interference with respiration; and the length of time the patient has survived the onset of the fits.

Clinical Varieties of Tetanus.—*Acute Traumatic Tetanus.*—This variety has been described as the type of the disease. It is characterised, as we have seen, by the rapidity of its progress, the severity of its symptoms, and its all but universally fatal issue in spite of treatment, death taking place in from one to four days.

Chronic Tetanus.—The difference between this and acute tetanus is mainly one of degree. Its incubation period is longer, it is more slow and insidious in its progress, and it never reaches the same degree of severity. Trismus is the most marked and constant form of spasm; and while the trunk muscles may be involved, those of respiration as a rule escape. Every additional day the patient lives adds to the probability of his ultimate recovery. When the disease does prove fatal it is from exhaustion, and not from respiratory or cardiac spasm. The usual duration is from six to ten weeks.

Trismus.—This term is used to denote a form of tetanic spasm limited to the muscles of mastication. It is really a mild form of chronic tetanus, and the prognosis is good. It must be diagnosed clinically from inflammatory lesions of the pharynx and alveoli of the jaws, and from affections of the temporo-maxillary articulation.

Tetanus Neonatorum is a form of tetanus occurring in infants of about a week old. Infection takes place through the umbilicus, and manifests itself clinically by spasms of the muscles of mastication. It is almost invariably fatal within a few days.

Head or Cephalic Tetanus.—This is a peculiar variety of traumatic tetanus which follows injuries to the head. It is characterised by the occurrence, on the same side as the head injury, of more or less complete paralysis of the facial muscles supplied by the seventh nerve, with trismus and other tetanic symptoms, varying in severity throughout the body.

The paralysis of the facial nerve fibres is believed to be due to a selective action of one of the tetanus toxins on the nerve centre in the medulla, as well as a local action on the peripheral nerve endings. In head tetanus the muscles of deglutition are often specially involved—hence the name *tetanus hydrophobicus*. The prognosis is on the whole grave.

Differential Diagnosis.—There is little difficulty, as a rule, in diagnosing a case of fulminating tetanus, but there are several conditions with which it may occasionally be confused. *Strychnine poisoning*—Here the spasms come on immediately after the patient has taken a toxic dose of the drug; they are tonic in character but the muscles are relaxed during the fits; the muscles of the jaws usually escape, whilst those of the hands are involved. If the dose is not lethal the spasms soon cease. In *hydrophobia* a history of having been bitten by a rabid animal is usually forthcoming; the spasms, which are clonic in character, affect chiefly the muscles of respiration and deglutition, and pass off entirely in the intervals between attacks. *Cerebro-spinal meningitis* and *basal meningitis* present certain superficial resemblances to tetanus, but there is no trismus, and the spasms chiefly affect the muscles of the neck and back. Certain cases of *hæmorrhage into the lateral ventricles* of the brain also simulate tetanus, but an analysis of the symptoms will prevent errors in diagnosis. *Hysteria and catalepsy* may assume characters resembling those of tetanus, but beyond the spasms there is nothing in common between these diseases. Lastly, the *tetany* of children, or that following operations on the thyroid gland, must not be confused with tetanus. In tetany the spasms are of a jerking character, affect chiefly the hands and fingers, and yield to medicinal treatment.

Prophylaxis.—The prevention of tetanus depends on thorough purification and careful antiseptic treatment of all wounds which have been liable to infection by earth, stable refuse, or street dust. All instruments and appliances used for operations on tetanic patients must be sterilised by *prolonged* boiling before being put away.

Treatment.—When symptoms of the disease have appeared, the indications for treatment are:—(1) *To arrest the formation and introduction into the circulation of further supplies of the toxin.* To this end the wound must be thoroughly purified by the usual means, the unhealthy walls being bodily excised and the raw surface left sponged over with carbolic acid and dressed with iodoform gauze. Amputation is never called for to meet this indication.

(2) *To promote excretion of the toxins already absorbed* by ensuring free action of the bowels, kidneys, and skin. The injection of saline solution into the veins or cellular tissue may be had recourse to with this object.

(3) *To counteract the toxins already in circulation.*—The value of the anti-tetanic serum is still in doubt. While it is true that a degree of immunity may be produced in animals by means of antitoxic serum, there is at present little evidence that any material benefit follows its use in acute progressive tetanus in the human subject. The vast majority of the cases in which the serum has been employed and the patient has recovered have been of the chronic type of the disease, which naturally tends to spontaneous cure. In spite of these facts, however, and in view of the success which has followed the use of other

sera, we are bound to give the patient the benefit of what is meanwhile the only rational treatment offering any hope of cure. The earlier the serum is injected the greater is that hope, and the initial dose must be a large one—not less than 60 c.c. Several smaller doses may subsequently be given within the first twenty-four hours if the symptoms do not abate. The best results hitherto seem to have been obtained by Tizzoni's serum.

It has been alleged that if the serum be injected directly into the cerebral tissue the results are better, but experience has not confirmed this statement. A small hole is drilled in the frontal bone, and the serum very slowly injected into the substance of the frontal lobe. The operation, however, is not devoid of risk even when performed with every precaution as to asepsis.

The subcutaneous injection of an *emulsion of rabbit's brain* has been followed by recovery in some cases; and considerable benefit has also been derived from the injection of 20 minims of a 2 per cent. solution of *carbolic acid* in the region of the wound.

(4) *To conserve the patient's strength by preventing or diminishing the severity of the spasms.*—The patient should be placed in a quiet room, and every form of disturbance rigidly avoided. Sedatives must be given in large doses. Chloral is perhaps the best, and the patient should rarely have less than 150 grains in twenty-four hours. When he is unable to swallow it should be given by the rectum. The administration of chloroform is of great value in conserving the strength of the patient by abolishing the spasms, and enabling the attendants to administer nourishment or drugs either through a stomach-tube or by the rectum. Extreme elevation of temperature is met by tepid sponging. It is necessary to use the catheter if retention of urine occurs.

HYDROPHOBIA.

Hydrophobia is an acute infective disease following on the bite of a rabid animal. The analogies existing between hydrophobia and other diseases of undoubted bacterial origin justify the belief that this disease is due to a specific organism, although it has not yet been demonstrated. In this country it most commonly follows the bite or lick of a rabid dog or cat. The virus appears to be communicated through the saliva of the animal, and the disease is most likely to develop when the patient is infected on the face or some other uncovered part. Only about one person out of three bitten by animals proved to be rabid suffer from the disease.

Rabies in the Dog.—The animal becomes depressed and listless, develops a depraved appetite, eating all kinds of rubbish and filth; is peculiarly irritable and snappish towards other dogs; and when it moves about, takes no notice of surrounding objects. The bark becomes hoarse; a thick ropy mucus collects in the mouth, and the creature has difficulty in swallowing, although it makes violent attempts to lap water. Paralysis of the lower jaw and of the limbs precedes death, which usually takes place in five or six days. The wild fury which is generally supposed to characterise a mad dog is usually conspicuous by its absence.

A dog which has bitten a person should on no account be killed until its condition has been proved one way or the other. Should rabies develop and its destruction become necessary, the head and spinal cord should be retained and forwarded, packed in ice, to a competent observer. Much anxiety to the person bitten and to his friends would be avoided if these rules were observed, because in many cases it will be shown that the animal did not after all suffer from rabies, and that the patient consequently runs no risk. If, on the other hand, rabies is proved to be present, the patient must be submitted to the Pasteur treatment.

Clinical Features in Man.—There is almost always a history of the patient having been bitten or licked by an animal supposed to suffer from rabies. The incubation period averages about forty days, but varies from a fortnight to seven or eight months, and is shorter in young than in old persons. The original wound has long since healed, and beyond a slight itchiness or pain shooting along the nerves of the part, shows no sign of disturbance. A few days of general malaise, with chills and giddiness, precede the onset of the acute manifestations, which affect chiefly the muscles of deglutition and respiration. One of the earliest signs is that the patient has periodically a sudden catch in his breathing "resembling what often occurs when a person goes into a cold bath." This is due to spasm of the diaphragm, and is frequently accompanied by a loud-sounding hiccough, likened by the laity to the barking of a dog. Difficulty in swallowing fluids may be the first symptom.

The spasms rapidly spread to all the muscles of deglutition and respiration, so that the patient not only has the greatest difficulty in swallowing, but has a constant sense of impending suffocation. To add to his distress, a copious secretion of viscid saliva fills his mouth. Any voluntary effort, as well as all forms of external stimuli, only serves to aggravate the spasms which are always induced by the attempt to swallow fluid, or even by the sound of running water.

The temperature is raised; the pulse is small, rapid, and intermittent, and the urine may contain sugar and albumin.

The mind may remain clear to the end, or the patient may have delusions, supposing himself to be surrounded by terrifying forms. There is always extreme mental agitation and despair, and the sufferer is in constant fear of his impending fate. Happily the inevitable issue is not long delayed, death usually occurring from exhaustion in from two to four days from the onset. The symptoms of the disease are so characteristic that there is no difficulty in diagnosis. The only condition with which it is liable to be confused is the variety of cephalic tetanus in which the muscles of deglutition are specially involved—the so-called tetanus hydrophobicus.

Prophylaxis.—The bite of an animal suspected of being rabid should be cauterised at once by means of the actual or Paquelin cautery, or by a strong chemical escharotic such as pure carbolic acid, after which antiseptic dressings are applied.

It is, however, to Pasteur's *preventive inoculation* that we must look for our best hope of averting the onset of symptoms. "It may now be taken as established that a grave responsibility rests on those concerned if a person bitten by a mad animal is not subjected to the Pasteur treatment" (Muir and Ritchie).

This method is based on the fact that the long incubation period of the disease admits of the patient being inoculated with a modified virus producing a mild attack, which protects him from the natural disease—on the same principle as vaccination for small-pox.

Treatment.—When the symptoms have once developed they can only be palliated. The patient must be kept absolutely quiet and free from all sources of irritation. The spasms may be diminished by means of chloral and bromides, or by chloroform inhalation. There is great difficulty in feeding the patient, and all nourishment and stimulants may require to be administered per rectum.

ANTHRAX.

Anthrax is a comparatively rare bacterial disease communicable to man from certain of the lower animals, such as sheep, oxen, horses, deer, and other herbivora. In animals it is characterised by symptoms of acute general septic poisoning, and, from the fact that it produces a marked enlargement of the spleen, is known in veterinary surgery as "splenic fever."

The *bacillus anthracis*, to the action of which the disease has been proved to be due, is the largest of the known pathogenic bacteria. It occurs in long chains made up of numerous bacilli, each measuring from 6 to 8 μ in length.

The organisms are found in enormous numbers throughout the bodies of animals which have died of anthrax, and are readily recognised and cultivated.

Sporulation only takes place outside the body, probably because free oxygen is necessary to the process. In the spore-free condition, the organisms are readily destroyed by ordinary germicides, such as heat, dryness, chemicals, or by the gastric juice. The spores, on the other hand, have a high degree of resistance. Not only do they remain viable in the dry state for long periods, even up to a year, but they survive boiling for five minutes, and must be subjected to dry heat at 140° C. for several hours before they are destroyed; nor are they affected by the gastric juice.

Clinical Varieties of Anthrax.—In man, anthrax may manifest itself in one of three clinical forms.

It may be transmitted by means of spores or bacilli directly from a diseased animal to those who, by their occupation or otherwise, are brought into contact with it—for example, shepherds, butchers, veterinary surgeons, or hide-porters. The path of infection is usually through an abrasion of the skin, and the primary manifestations are local, constituting what is known as *the malignant pustule.*

In other cases the disease is contracted through the inhalation of the dried spores into the respiratory passages. This occurs oftenest in those who work amongst wool, fur, and rags, and an affection resembling an acute septic pneumonia of great virulence ensues. This affection is known as *wool-sorter's disease*, and is almost universally fatal.

There is reason to believe that infection may also take place by means of spores ingested into the alimentary canal in meat or milk derived from diseased animals, or in infected water. Acute and severe gastro-intestinal symptoms follow, and the mesenteric glands become greatly enlarged.

Clinical Features of Malignant Pustule.—The clinical features of anthrax as it occurs in the respiratory and alimentary systems are chiefly of interest to the physician. We shall therefore confine ourselves here to the consideration of the local lesion as it occurs in the skin—*the malignant pustule.*

The point of infection of malignant pustule is usually on an uncovered part of the body, such as the face, hands, arms, or back of the neck, and the wound of infection may be exceedingly minute. After an incubation period varying from a few hours to three or four days, a small red nodule, surrounded by a reddish-blue bleb containing clear or blood-stained fluid, appears at the seat of inoculation. This is accompanied by a slight burning pain and intense itchiness. The bleb soon bursts and forms a black, dried scab, around which one or more rings of small vesicles form. Outside this the skin becomes indurated and swollen, and a widespread œdema occurs. When the seat of inoculation is in the vicinity of the neck, this œdema may implicate the larynx and lead to dangerous interference with respiration. The neighbouring lymphatic glands soon become enlarged and tender.

The great danger in malignant pustule is the occurrence of general anthrax infection—*anthracæmia.* When this occurs it shows itself in the course of forty-eight to sixty hours in the form of fever, with a temperature of 102° to 104° F., severe general pains in the limbs, diarrhœa, hæmaturia, and great weakness. The patient is usually remarkably free from anxiety and distress, even when dangerously ill, and dies in the course of from five to eight days with symptoms of collapse.

Profuse suppuration, with sloughing of considerable portions of the skin and subcutaneous tissue, may take place at the seat of the primary lesion.

Morbid Anatomy.—The central slough is composed of necrosed tissue and altered blood. The surrounding skin is intensely congested and œdematous, and the stratum corneum is raised as a blister from the rete Malpighi. The bacilli are found in the peripheral portion of the slough, in the vesicles, and in the adjacent lymphatics. In man the spleen is not markedly enlarged, and organisms are not found in any numbers throughout the body.

Differential Diagnosis.—The occupation of the patient is a valuable guide in diagnosis. An ordinary boil is distinguished from the primary nodule of anthrax by the greater pain which attends its formation, its conical shape, the appearance of the yellow slough at its apex, and by the absence of the black centre and the surrounding ring of vesicles. The same remarks apply to the differential diagnosis from carbuncle.

The early appearance of the blebs, their giving place to black crusts, and the intensity of the swelling serve to distinguish anthrax from erysipelas and diffuse cellulitis. *Malignant œdema* is liable to be confused with a rapidly-spreading malignant pustule. So closely do the local manifestations of the two diseases resemble one another that it is often only by bacteriological examination that they can be distinguished.

Prognosis.—If left to itself the disease is frequently fatal. The mortality is greatest when the disease attacks the face or neck, and least when the inferior extremity is affected. Opinions differ as to the value of surgical interference.

Prophylaxis.—Any wound suspected of being infected by the anthrax bacillus should at once be cauterised with the actual cautery, then sponged over with pure carbolic acid, and dressed antiseptically.

Treatment.—Where it is possible, the whole of the affected area should be excised without delay, and the actual cautery and pure carbolic acid freely applied to the raw surface. An antiseptic dressing is then applied.

When complete excision is impracticable on account of the situation or extent of the disease, or its relation to important structures, the whole of the indurated area should be freely incised, and after clipping away all necrotic tissue with scissors, the raw surface should be cauterised.

The subcutaneous injection of strong solutions of carbolic acid or corrosive sublimate has in many cases yielded satisfactory results.

It is only fair to state, however, that the experience of other observers seems to indicate that the results obtained by leaving

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the pustule to nature and merely protecting it with an antiseptic dressing are equally good.

The general treatment consists in feeding and stimulating the patient as freely as possible. Quinine, in 5 to 10 grain doses every four hours, and powdered ipecacuanha, in 40 to 60 grain doses every four hours, have also been employed with benefit.

GLANDERS.

Glanders is due to the action of a specific bacterium, the *bacillus mallei*, which resembles the tubercle bacillus, save that it is somewhat shorter and broader, and refuses the stains used for that organism. It requires higher temperatures for its cultivation than the tubercle bacillus, and its growth on potato is of a characteristic chocolate-brown colour, with a greenish-yellow ring at the margin of the growth. The bacillus mallei retains its vitality for long periods under ordinary conditions, but is readily killed by heat and chemical antiseptics. It does not form spores.

Clinical Features.—Both in the lower animals and in man the bacillus gives rise to two distinct types of disease—*acute glanders*, and *chronic glanders or farcy.*

Acute Glanders is most commonly met with in the horse and in other equine animals, while horned cattle are immune. It affects the septum of the nose and adjacent parts, in the mucous membrane of which firm, translucent, greyish nodules containing lymphoid and epithelioid cells appear. These subsequently break down in the centre and give rise to irregular ulcerations, with profuse discharge, and marked inflammatory swelling around them. The cervical lymphatic glands, as well as the lungs, spleen, and liver, may be the seat of secondary nodules.

In man acute glanders is commoner than the chronic variety. Infection always takes place through an abraded surface, and usually on one of the uncovered parts of the body—most commonly the skin of the hands, arms, or face; or on the mucous membrane of the mouth, nose, or eye. The disease has been acquired by accidental inoculation in the course of experimental investigations in the laboratory, and has proved fatal. The incubation period is from three to five days.

The *local* manifestations are pain and swelling in the region of the infected wound, with inflammatory redness around it and along the lines of the superficial lymphatics. In the course of a week, small, firm nodules, with an œdematous, inflammatory base, appear, and are rapidly transformed into pustules. These may occur on the face and in the vicinity of joints, and may be mistaken for the eruption of small-pox.

After breaking down, these pustules give rise to irregular, ulcerated surfaces, which by their confluence lead to extensive destruction of skin. Sometimes the nasal mucous membrane becomes affected and produces a discharge—at first watery, but later sanious and purulent. Necrosis of the bones of the nose may take place, in which case the discharge becomes peculiarly offensive. In nearly every case metastatic abscesses form in different parts of the body, such as the lungs, joints, or muscles.

During the development of the disease the patient feels ill, complains of headache and pains in the limbs, the temperature rises to 104° or even to 106° F., and assumes a pyæmic type. The pulse becomes rapid and weak. The tongue is dry and brown. There is profuse sweating, albuminuria, and often insomnia with delirium. Death may take place within a week, but more frequently occurs from exhaustion during the second or third week.

Differential Diagnosis.—There is nothing characteristic as to the site of the primary lesion in man, and the condition may, during the early stages, be mistaken for a boil or carbuncle, for erysipelas, or for any of the other acute superficial inflammatory conditions. Later it may simulate acute articular rheumatism, or may manifest all the symptoms of acute septicæmia or pyæmia. The diagnosis is established by the isolation of the bacillus.

The *prophylaxis* consists in thorough disinfection of any wound subjected to infection by contact with a diseased animal.

Treatment.—Excision of the primary nodule, followed by cauterisation with a red-hot iron and sponging with pure carbolic acid, should be carried out if the disease is recognised early, or at any time, provided the condition is sufficiently limited to render complete removal practicable.

When secondary abscesses form in accessible situations they must be incised, scraped, disinfected, and drained. The general treatment is carried out on the same lines as in other acute infective diseases.

Chronic Glanders.—*In the horse* the chronic form of glanders is known as *farcy*. It follows infection through an abrasion of the skin, and involves chiefly the superficial lymphatic vessels and glands. The lymphatics become firm and nodular, constituting what the veterinarians call *farcy pipes* and *farcy buds*.

In man also the clinical features of the chronic variety of the disease are somewhat different from those of the acute form. Here, too, infection takes place through a broken cutaneous surface, and leads to a superficial lymphangitis with nodular thickening of the lymphatics (*farcy buds*). The neighbouring glands soon become swollen and indurated. The primary lesion meanwhile inflames, suppurates, and after breaking down leaves a large, irregular ulcer with thickened edges and a foul, purulent or bloody discharge. The glands break down in the same way and lead to wide destruction of skin, and the resulting sinuses and ulcers are exceedingly intractable (Fig. 24). Secondary deposits in the subcutaneous tissue, the muscles, and other parts are not uncommon, and the nasal mucous membrane may become involved. The disease often runs a very chronic course, extending to four or five months, or even longer. Recovery takes place in about 50 per cent. of cases, but the convalescence is very prolonged, and at any time the disease may assume the characters of the acute variety and speedily prove fatal.

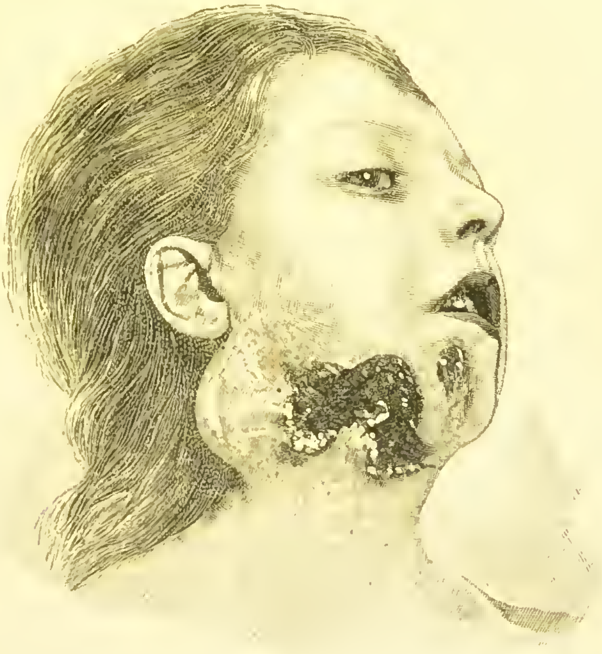

FIG. 24.—Chronic Glanders in a girl æt. 15. Shows Multiple Ulcers and Enlarged Glands.

The *differential diagnosis* is often very difficult. The ulcerations of farcy have to be distinguished from those of tubercle, syphilis, and other forms of infective granulomata. In the chronic nodules it is often impossible to demonstrate the bacillus.

Treatment.—Limited areas of disease should be completely excised, disinfected with pure carbolic acid, and dressed antiseptically. When too widely spread for this, incision of abscesses, followed by scraping and disinfection, is all that can be attempted.

The general condition of the patient must be improved by tonics, good food, and favourable hygienic surroundings. In some cases potassium iodide acts beneficially.

ACTINOMYCOSIS.

Actinomycosis is a chronic disease due to the action of an organism somewhat higher in the vegetable scale than ordinary bacteria—the *streptothrix actinomyces* or *ray fungus.*

Etiology and Morbid Anatomy.—The actinomyces, which has never been met with outside the body, gives rise in oxen, horses, and other animals to tumour-like masses composed of granulation tissue; and in man to chronic suppurative processes which may result in a condition resembling chronic pyæmia. The actinomyces is more complex in structure than other pathogenic organisms, and occurs in the tissues in the form of small, round, semi-translucent bodies, about the size of a pin-head or less, and consisting of colonies of the fungus. On account of their yellow tint they are spoken of as "sulphur grains." Each colony is made up of a series of thin, interlacing and branching *filaments,* some of which are broken up so as to form masses or chains of *cocci;* and around the periphery of the colony are elongated, pear-shaped, hyaline, *club-like bodies.*

Infection is believed to be conveyed by the husks of cereals, especially barley; and the organism has been found adhering to particles of grain embedded in the tissues of animals suffering from the disease. In human subjects there is often a history of exposure to infection from such sources, and the disease is said to be most common during the harvesting months.

Around the colonies of actinomyces is an area of chronic inflammation in which suppuration usually occurs, so that the fungus comes to lie in a bath of greenish-yellow pus. Outside the pus is a layer of granulation tissue. As the process spreads the small abscesses become confluent and form larger cavities.

When metastasis takes place the fungus is transmitted by the blood-vessels, as in pyæmia.

Clinical Features.—In man the disease may be met with *on a cutaneous surface*, but this is not common. The organisms gain access through a broken surface, and spread by the formation of new nodules in the same way as tuberculosis of the skin. They may, however, pass deeply and involve any of the underlying tissues. The lymphatic glands are not involved—a point which may serve to distinguish this disease from tuberculosis.

The region of the *mouth and jaws* is one of the commonest sites of surgical actinomycosis. Infection takes place, as a rule, along the side of a carious tooth, and spreads to the lower jaw. A swelling is slowly and insidiously developed, and a condition closely resembling a periosteal sarcoma results. The loose connective tissue of the neck becomes infiltrated, and then the spread is more rapid. The whole region becomes swollen and infiltrated, and the skin ultimately gives way and free suppuration occurs, resulting in the formation of persistent sinuses. The characteristic greenish-grey or yellow granules are seen in the pus, and when examined microscopically reveal the colonies of actinomyces.

Less frequently the upper jaw becomes affected, and the disease may spread to the base of the skull and brain and end fatally.

The *vertebræ* may become involved by infection taking place through the pharynx or œsophagus, and leading to a condition simulating tuberculous disease of the spine.

This disease comes under the notice of the physician when it implicates the intestinal canal and its accessory glands, the lungs, pleura and bronchial tubes, the brain, or the female genital tract.

Differential Diagnosis.—The conditions likely to be mistaken for surgical actinomycosis are sarcoma, tubercle, and syphilitic gumma. In the early stages the differential diagnosis is exceedingly difficult. In many cases it is only possible when suppuration has occurred and the fungus can be demonstrated.

The slow destruction of the affected tissue by suppuration, the absence of pain, tenderness, and redness simulate *tuberculosis*, but the absence of glandular involvement serves to distinguish it.

Syphilis may be excluded by a consideration of the history of the patient, but benefit from the administration of potassium iodide is likely to follow in both diseases. When the pleura is affected the condition is very liable to be mistaken for an ordinary pyogenic or a tuberculous empyema.

The recognition of the fungus is the crucial point in diagnosis.

Prognosis.—Spontaneous cure rarely occurs. When the disease implicates internal organs it is almost always fatal. On external parts the destructive process gradually spreads, and the patient eventually succumbs to septic poisoning, pyæmia, and exhaustion. Metastasis is very rare. When the primary focus from its situation admits of surgical treatment the prognosis is more favourable.

Treatment.—The only surgical treatment to be seriously considered is the early and free removal of the affected tissues. After excision the wound is cauterised by the actual cautery and sponged over with pure carbolic acid. The cavity left is packed with iodoform gauze, no attempt being made to close the wound by stitches. Local recurrences are treated in the same way.

The administration of potassium iodide in large doses is of great benefit in the treatment of actinomycosis, and in cases in which operative treatment is impracticable, is the most reliable measure at our disposal.

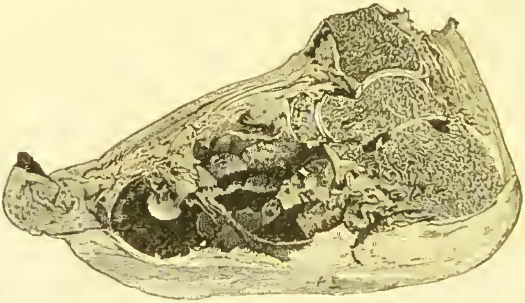

FIG. 25.—Mycetoma, or Madura Foot.

(Museum of Royal College of Surgeons, Edinburgh.)

MYCETOMA OR MADURA FOOT.—Mycetoma is a very chronic disease due to an organism resembling that of actinomycosis, but not identical with it. It is endemic in certain tropical countries, and is most frequently met with in India. Infection takes place through the skin. An abrasion is doubtless necessary for the introduction of the organism. The disease usually occurs on the feet of adult males who work barefooted in the fields—hence the name "Madura foot."

Clinical Features.—The disease begins on some part of the foot as an indurated patch, which becomes discoloured and permeated by black or yellow nodules containing the organism. These nodules spread through the foot, break down by suppuration, and numerous minute abscesses lined by granulation tissue are thus formed. In the pus yellow particles likened to fish-roe, or black-pigmented granules like gunpowder, are constantly found. Sinuses form, and the whole foot becomes greatly swollen and distorted by flattening of the sole and hyper-extension of the toes. Areas of caries or necrosis occur in the bones of the foot (Fig. 25);

and the disease gradually extends up the leg. There is but little pain, and no constitutional disturbance. The glands are not implicated, nor are secondary lesions ever produced. The disease may run a very prolonged course lasting for twenty or thirty years. Spontaneous cure never takes place, and the risk to life is that of prolonged suppuration.

Treatment.—If the disease be localised it may be removed by the knife or sharp spoon, and the part afterwards cauterised and sponged over with pure carbolic acid. As a rule, however, amputation well above the disease is the best line of treatment. Unlike actinomycosis, this disease does not appear to be benefited by potassium iodide.

DELHI BOIL.—*Synonyms*—Aleppo boil, Biskra button, Furunculus orientalis, Natal sore.

Delhi boil is a chronic inflammatory disease, most commonly met with in India, especially towards the end of the wet season. The disease occurs oftenest on the face, and is believed to be due to an organism, although this has not been demonstrated. The infection is supposed to be conveyed through water used for washing or by the bites of insects.

Clinical Features.—A red spot, resembling the mark of a mosquito bite, appears on the affected part, and is attended with marked itching. After becoming papular and increasing to the size of a pea, desquamation takes place, leaving a dull-red surface, which in the course of several weeks develops over itself a series of small yellowish-white spots, from which serum exudes, and, drying, forms a thick scab. Under this scab the skin ulcerates, leaving small oval sores with sharply-bevelled edges, and an uneven floor covered with yellow or sanious pus. These sores vary in number from one to forty or fifty. They may last for months and then heal spontaneously, or may continue to spread until arrested by suitable treatment. There is no enlargement of adjacent glands, and but little inflammatory reaction in the surrounding tissues; nor is there any marked constitutional disturbance. Recovery is often followed by considerable cicatricial contraction leading to marked deformity of the face.

The *treatment* consists in destroying the original papule by the actual cautery, acid nitrate of mercury, or pure carbolic acid. The ulcers should be scraped with the sharp spoon, painted with pure carbolic, and dressed with iodoform gauze. The patient should, if possible, leave the district in which the disease is endemic, and should only use water sterilised by boiling.

CHIGOE.—Chigoe or jigger results from the introduction of the eggs of the sand flea (*pulex penetrans*) into the tissues. It occurs in tropical Africa, South America, and the West Indies. The impregnated female flea remains attached to the part till the eggs mature, when by their irritation they cause localised inflammation with pustular or vesicular swelling. Children are most commonly attacked, particularly about the toe nails and on the scrotum. The treatment consists in picking out the insect with a blunt needle, special care being taken not to break it up. The puncture is then cauterised. The application of essential oils to the feet acts as a preventive.

POISONING BY INSECTS.—The bites of certain insects, such as mosquitoes, midges, different varieties of flies, wasps, and spiders, may be followed by serious complications. The effects are mainly due to the injection of an irritant acid secretion, the exact nature of which has not been ascertained. Some persons are more susceptible than others. It is important to note also that insects may carry the specific virus of such diseases as malaria, filaria, anthrax, or Delhi boil, or the ordinary pyogenic bacteria.

The local lesion is a puncture, surrounded by a zone of hyperæmia, wheals, or vesicles, and is associated with burning sensations and itching, which usually pass off in a few hours, but may recur at intervals, especially when the patient is warm during the night. Scratching also reproduces the local signs and symptoms. Where the connective tissue is loose—for example, in the eyelids or scrotum—there is often considerable swelling; and in the mouth and fauces this may lead to œdema glottidis, which may prove fatal.

The *treatment* consists in the local application of dilute alkalies such as ammonia water, solutions of carbonate or bicarbonate of soda, or sal volatile. Weak carbolic lotions, or lead and opium lotion, are useful in allaying the local irritation. One of the best means of neutralising the poison is to apply to the sting a drop of a mixture containing equal parts of pure carbolic acid and ammonia.

Free stimulation is called for when severe constitutional symptoms are present.

SNAKE-BITES.—We are here only concerned with the injuries inflicted by the venomous varieties of snakes, the most important of which are the hooded snakes of India, the rattlesnakes of America, the horned snakes of Africa, the viper of Europe, and the adder of the United Kingdom.

While the virulence of these creatures varies widely, they are all capable of producing in a greater or less degree symptoms of acute poisoning in man and other animals. By means of two recurved fangs attached to the upper jaw, and connected by a duct with poison-secreting glands, they introduce into their prey a thick, transparent, yellowish fluid, of acid reaction, probably of the nature of an albumose, and known as the *venom*.

The *clinical features* resulting from the injection of the venom vary directly in intensity with the amount of the poison introduced, and the rapidity with which it reaches the circulating blood, being most marked when it immediately enters a large vein. The poison is innocuous when taken into the stomach.

Locally the snake inflicts a double wound, passing vertically into the subcutaneous tissue; the edges of the punctures are ecchymosed, and the adjacent vessels the seat of thrombosis. Immediately there is intense pain, and considerable swelling with congestion, which tends to spread towards the trunk. Extensive gangrene may ensue. There is no special involvement of the lymphatics.

The *general symptoms* may come on at once if the snake be a particularly venomous one, or not for some hours if less virulent. In the majority of viper or adder bites the general constitutional disturbance is slight and transient, if it appears at all. Snake-bites in children are particularly dangerous.

The patient's condition is one of profound shock with faintness, giddiness, dimness of sight, and probably loss of speech, and a feeling of great terror. The pupils dilate, the skin becomes moist with a clammy sweat, and nausea with vomiting, sometimes of blood, ensues. High fever, cramps, loss of sensation, hæmaturia, and melæna are among the other symptoms which may be present. The pulse becomes feeble and rapid, the respiratory nerve centres are profoundly depressed, and delirium followed by coma usually precedes the fatal issue, which may take place in from five to forty-eight hours. If the patient survive for two days the prognosis is favourable.

Treatment.—A broad ligature should be tied tightly round the limb just above the seat of infection to prevent the poison passing into the general circulation. Bleeding from the wound should be encouraged, and, if necessary, incisions may be made for this purpose. The application of an Esmarch's elastic bandage from above downward to empty the blood out of the infected portion of the limb has been recommended. The whole of the bite should at once be excised, and the raw surface treated with a solution of permanganate of potash or peroxide of hydrogen, which destroys the poison by oxidation.

The general treatment consists in free stimulation with whisky, brandy, ammonia, digitalis, etc. Hypodermic injections of strychnine in doses sufficiently large to produce a slight degree of poisoning by the drug are particularly useful. The most rational treatment, when it is available, is the use of the *antivenin* introduced by Fraser and Calmette.

CHAPTER IX.

TUBERCULOSIS.

Definition of tuberculous disease—Tubercle bacilli—Methods of infection—Inherited and acquired predisposition—Action of the bacillus upon the tissues—Tuberculous granulation tissue—Natural cure—Recrudescence of the disease—THE TUBERCULOUS ABSCESS—Contents and wall of the abscess.

THE term tuberculosis is applied generically to the various pathological conditions which result from the action of the tubercle bacillus. The diseases produced by this organism are spoken of as *tuberculous*, and as this term indicates the essential nature of the affection, it is to be preferred to the terms "strumous" and "scrofulous" previously employed.

Tuberculosis may be met with in any of the tissues or organs of the body, but it occurs more frequently in some situations than in others. It is very common, for example, in lymphatic glands, in bones and joints, in the peritoneum, the intestine, the kidney, prostate and testis, and in the skin and subcutaneous cellular tissue. It is seldom met with in the breast or in muscles, and it rarely affects the ovary, the pancreas, the parotid, or the thyroid.

Tubercle bacilli occur as straight or slightly-curved rods, measuring about 3 μ by ·3 μ. They have no power of movement. It is as yet undecided whether or not they form spores. Their virulence varies widely, and they are more tenacious of life than the common pyogenic bacteria. In a dry state, for example, they can retain their vitality for months, and they can also survive immersion in water for prolonged periods. They resist the action of the products of putrefaction for a considerable time, and are not destroyed by digestive processes in the stomach and intestine. They may be killed in a few minutes by immersion in 1 in 20 carbolic lotion, by boiling, or by exposure to steam under pressure.

"The great multiplying ground of tubercle bacilli is the animal body, and tuberculous tissues and secretions containing the bacilli are the chief, if not the only means by which the disease is spread. The bacilli leave the body in large numbers in the sputum of phthisical patients, and when the sputum becomes dried and pulverised they are set free in the air. Their presence in the air of rooms containing consumptive patients has been repeatedly demonstrated. So far as the human subject is concerned, the great means of disseminating the bacilli in the outer world is dried phthisical sputum. Another possible source of infection, especially in children, is the milk of cows affected with tuberculosis of the udder."[1]

In marked contrast to what obtains in the infective diseases which have been already described, tuberculosis rarely results from the infection of a wound of the external surface of the body. In exceptional instances, however, this does occur, and in illustration of the fact may be cited the case of a servant girl who cut her finger with a broken spittoon containing the sputum of her consumptive master; the wound subsequently showed evidence of tuberculous infection, which ultimately spread up along the lymphatic vessels of the arm. Pathologists, too, whose hands are frequently exposed to the contact of tuberculous tissues and pus, are liable to suffer from a form of tuberculosis of the skin of the finger, known as *anatomical tubercle.* Slight wounds of the feet in children who go about barefoot in towns sometimes become infected with tubercle. Operation wounds made with instruments contaminated with tuberculous material have also been known to become infected. It is highly probable that the common form of tuberculosis of the skin known as "lupus" arises by direct infection from without.

In the vast majority of cases the tubercle bacillus gains entrance to the body by way of the internal mucous surfaces, the organisms being either inhaled or swallowed.

The respiratory mucous membrane, from the nose and mouth to the terminations of the air tubes in the lungs, is constantly exposed to infection by the inhalation of air laden with dust and other minute particles to which the virus is adherent. The existence of inflammation, or of some superficial lesion of these mucous surfaces, favours the entrance of the bacilli into the tissues, whence they pass by way of the lymphatic vessels to the glands. The glands most frequently infected in this way are the cervical glands, and those within the cavity of the chest—particularly the bronchial glands at the root of the lung.

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[1] Muir and Ritchie, "Manual of Bacteriology," 3rd edition, 1902.

The entrance of the bacilli into one or other of these groups of glands may result in active tuberculous disease of the infected group. On the other hand, there is reason to believe that the organisms may lie in a dormant or latent condition for an almost indefinite period, and only become active long afterwards, when some general depression of the patient's health produces conditions which favour their growth. When the organisms become active in this way, the tuberculous tissue may undergo softening and disintegration, the infective material may erupt into an adjacent vein, and thus entering the general circulation, may be carried by the blood-stream to distant parts of the body, and so give rise to an acute general tuberculosis. The initial infection of the lymphatic glands within the chest, being unattended with any external or clinical evidence of its occurrence, remains unrecognised and unsuspected, and the patient, usually a child, may present the appearances of even robust health. At any subsequent period of life, however, tuberculous disease may make its appearance in some tissue of the body—for example, in a bone or joint, in the kidney or testicle, or in the membranes of the brain. More than one tissue may be infected either simultaneously or in succession, without any external evidence of the transference of the bacilli from one part of the body to another. Many tuberculous patients are to be regarded as possessing in their bronchial glands, or elsewhere, an internal store of bacilli, to which the existing disease owes its origin, and from which similar outbreaks of tuberculosis may originate in the future.

It is probable that in some cases the tubercle bacilli may effect an entrance through the mucous membrane of the respiratory tract directly into the blood-vessels, and thus into the circulating blood, by means of which they may be carried to any part of the body.

The alimentary mucous membrane, especially that of the small intestine, is exposed to infection by swallowed sputum and by food materials, such as milk, containing tubercle bacilli. The organisms may lodge in the mucous membrane and cause tuberculous ulceration, or they may be carried through the wall of the bowel into the lacteals, along which they pass to the mesenteric glands. There they may become arrested, and either give rise to active tuberculous disease of the glands, or lie dormant indefinitely and only become active at a subsequent period. It may happen that the bacilli from a tuberculous mesenteric gland are carried by way of the receptacle of the chyle and the thoracic duct into the general circulation, and in this way infect distant parts of the body, or give rise to general tuberculosis. In some cases the transference of the infective material is more direct—for example, when a softened mesenteric gland erupts into a contiguous vein, and so infects the circulating blood, or erupts on to the peritoneum covering the mesentery, and so sets up a tuberculous peritonitis.

Predisposition to Tuberculosis.—That some individuals are more prone to become the subjects of tuberculosis than others is evident from the fact that while under the existing conditions of civilised life all are exposed to the infection, only a comparatively small number acquire the disease. The precise conditions which favour the entrance, lodgment, and growth of the bacilli in those predisposed to the disease are somewhat uncertain. It may be that there is some peculiarity of the tissues which renders them a specially suitable soil for the organisms, or that the patient's power of resisting the invasion of the virus is abnormally low. In any case, with regard to the etiology of tuberculosis, this predisposition is to be looked upon as a factor almost as important as the presence of the bacilli themselves. In some cases the predisposition is inherited, in others it is acquired.

Those who *inherit* the predisposition usually belong to families in which the disease is specially rife, and although as children they may have all the appearance of being healthy and even robust, if exposed to infection they are much more liable to contract tuberculosis than are members of families in which the disease is unknown. The inherited predisposition dates from the commencement of life, and only terminates with it. Children are very seldom born with tuberculous lesions, and in the recorded cases of congenital tuberculosis there has almost always been some tuberculous disease present in the generative organs of the mother.

There is abundant evidence that the common diseases of infancy and childhood,—such, for example, as whooping-cough, measles, influenza, bronchial catarrh, broncho-pneumonia, and rickets,—by impairing the general health and lowering the resisting powers of the individual, exert an important influence in producing an *acquired* predisposition to tuberculosis. Tuberculous affections frequently date from an attack of one or other of these illnesses, the inflamed and catarrhal condition of the respiratory and other mucous membranes doubtless favouring the occurrence of tuberculous infection. Confinement in crowded dwellings, schoolrooms, workshops, and factories is also injurious, as it entails the breathing of impure air which may be contaminated with tubercle bacilli. Insufficient and improper feeding, by lowering the general vitality and by leading to impairment of digestion and catarrhal changes in the alimentary mucous membranes, have also a prejudicial influence.

In practice it is not uncommon to meet with a combination of the above-mentioned predisposing factors, all conspiring to render the soil more favourable for the growth of tubercle.

The effects of injury or of pre-existing disease in a part may favour the lodgment and growth of tubercle bacilli, but they are more likely to act in determining the localisation of the tuberculous disease than by directly contributing to its causation. In an individual, for example, in whose blood tubercle bacilli are circulating and reaching every tissue and organ of the body, the occurrence of tuberculous disease in a particular part may be determined by the depression of the tissues resulting from an injury.

Statistics show that the largest number of cases of surgical tuberculosis are met with between the ages of five and fifteen. At the same time, this apparent excessive frequency during the early years of life is partly accounted for by the correspondingly larger number of individuals alive during these years. Stated in another way, tuberculosis may be comparatively rare above the age of seventy, but so are individuals. It must be emphasised that tuberculosis may be met with at any period of life, and that the mere fact that a patient is up in years is not a sufficient reason for excluding the possibility of a given lesion being tuberculous. In individuals past the prime of life there is little tendency to natural recovery from tuberculous affections, and small prospect of any but the most radical operations effecting a cure of the disease.

While it is a fact that males are, on the whole, more often affected than females, the influence of sex in predisposing to tuberculosis is not certain.

Changes in the Tissues following upon the successful Lodgment of Tubercle Bacilli.—The action of the bacillus on the tissues is twofold: on the one hand, by its irritation it induces tissue reaction in the form of proliferative changes and leucocyte infiltration; and, on the other, it causes in the cells around degenerative changes which ultimately result in their death.

The area of tissue infected becomes the seat of a chronic inflammation, attended with the formation of a friable, gelatinous granulation tissue. This may be collected into circumscribed nodules or "tubercles," or it may be ill-defined, diffuse, and infiltrating. This granulation tissue presents characteristic histological elements—for example, large cells, often with more than one nucleus, spoken of as endothelioid cells; and still larger cells, known as giant cells. There are also large numbers of small round cells which resemble the leucocytes of the blood and lymph. It is further characteristic of tuberculous granulation tissue that it tends to undergo certain forms of degeneration and death, of which the best known is caseation. This implies the conversion of the tissue into an amorphous, pale-yellow or whitish material resembling cheese. Lime salts may subsequently be deposited in this material—a change known as calcification.

In any portion of tissue examined for diagnostic purposes the recognition of the characteristic elements above described, with or without caseation, is usually sufficient evidence of its tuberculous nature. The recognition of the bacillus itself by appropriate methods of staining makes the diagnosis a certainty; but as it is by no means easy to identify it in many forms of surgical tuberculosis, it may be necessary to have recourse to the more certain test of experimental inoculation.

The changes subsequent to the formation of tuberculous granulation tissue are liable to many variations. It must always be borne in mind that although the bacilli have effected a lodgment and have inaugurated disease, the relation between them and the tissues remains one of mutual antagonism; which of them is to gain and keep the upper hand in the conflict depends on their relative powers of resistance. If the tissues prevail, there ensues a process of repair. In the immediate vicinity of the area of infection young connective tissue, and later, fibrous tissue is formed. This may entirely replace the tuberculous tissue and bring about repair—a fibrous cicatrix remaining to mark the scene of the previous contest. Scars of this nature are not infrequently discovered at the apex of the lung after death. Under other circumstances the tuberculous tissue which has undergone caseation, or even calcification, is only encapsulated by the new fibrous tissue, like a foreign body. Although this may be regarded as a victory for the tissues, the cure, if such it may be called, is not always a permanent one, for at any subsequent period of life, when the part affected is disturbed by injury or through some other influence, the encapsulated tubercle may become active, may get the upper hand of the tissues, and there results what is called a relapse or recrudescence of the disease.

If, however, at the inauguration of the tuberculous disease the bacilli prevail, the infection tends to spread into the tissues surrounding those originally infected; more and more tuberculous granulation tissue is formed. Finally the tuberculous tissue breaks down and liquefies, resulting in the formation of a cold abscess. In their struggle with the tissues, tubercle bacilli receive considerable support and assistance from the presence of pyogenic organisms. A tuberculous infection may exhibit its aggressive qualities in a more serious form by sending off detachments of bacilli, which are carried by the lymphatics to the nearest glands, or by the blood-stream to more distant, and it may be to all, parts of the body. When the infection is thus generalised, the condition is called "general tuberculosis." Considering the extraordinary frequency of localised forms of surgical tuberculosis, general dissemination of the disease is very rare.

The clinical features of surgical tuberculosis vary with the situation, distribution, and nature of the lesion. The onset of the disease is usually attended with impairment of the general health and vigour. It is a common observation that the patient has been losing flesh and is not taking the usual quantity of food. The more advanced symptoms—fever, sweating, and emaciation—are to be ascribed to the absorption and distribution throughout the system of the toxic products, not only of the tubercle bacilli, but also of other, and especially of pyogenic organisms, with which, in its later stages, the tuberculous infection is often complicated.

The general treatment consists in combating the adverse influences which have been mentioned as increasing the liability to tuberculous infection. Within recent years the value of the "open-air" treatment has been widely recognised. The diet must be a liberal one, and should include those articles which are at the same time nourishing and easily digested, especially proteids and fats; milk obtained from a reliable source is one of the best. When the ordinary nourishment taken is insufficient, it may be supplemented by such articles as malt extract, stout, and cod-liver oil. The last is especially beneficial in patients who do not take enough fat in other forms. It is noteworthy that many tuberculous patients show an aversion to fat in any form. Cod-liver oil should be given in small quantities until the patient becomes accustomed to it. When the oil continues to be distasteful or to disagree in the pure state, one or other of the emulsified forms may be substituted. The general health may be benefited by the administration of tonics—such, for example, as the syrup of the iodide of iron. The local treatment will be considered under each particular tissue and organ.

TUBERCULOUS ABSCESS.

The breaking-down of a tuberculous focus and the conversion of the debris into pus is a slow and insidious process, and is unattended with the classical signs of inflammation—hence the terms "cold" and "chronic" applied to the tuberculous abscess.

In a typical cold abscess, such as that which results from tuberculous disease of the vertebræ, the clinical appearances are those of a soft, fluid swelling without heat, redness, pain, or fever. When inflammatory symptoms are present they are usually due to a mixed infection with ordinary pyogenic bacteria having taken place.

A tuberculous abscess results from the disintegration and liquefaction of tuberculous granulation tissue which has undergone caseation. Fluid and cells from the adjacent blood-vessels exude into the cavity, and lead to variations in the character of its contents. In some cases the contents consist of a clear amber-coloured fluid, in which are suspended flakes or fragments of broken-down caseated tissue; in others, of a thick, white material like cream-cheese. From the addition of a large number of emigrated leucocytes, the contents may closely resemble the pus of an ordinary acute abscess.

The wall of the abscess is lined with tuberculous granulation tissue, the inner layers of which are undergoing caseation and disintegration and present a shreddy appearance. The outer layers consist of tuberculous tissue which has not yet undergone caseation. The abscess tends to increase in size by progressive liquefaction of the inner layers, caseation of the outer layers, and the further invasion of the surrounding tissues by tubercle bacilli. In this way a tuberculous abscess is capable of indefinite extension and increase in size until it reaches a free surface and ruptures externally. Once a collection of tuberculous pus forms, the direction in which it spreads is influenced by the anatomical arrangement of the tissues, and possibly to some extent by gravity, and the abscess may come to the surface at a considerable distance from its seat of origin. The best illustration of this is seen in psoas abscess, which may originate in the dorsal vertebræ, extend downwards within the sheath of the psoas muscle, and finally appear in the thigh.

Clinical Features.—The slow and insidious development of the tuberculous abscess is one of its most characteristic features.

The swelling may attain a considerable size without the patient being aware of its existence, and, as a matter of fact, it is often discovered accidentally. There is an absence of the ordinary signs of inflammation; but if the patient is under observation, and a record kept of the daily temperature, a slight rise may be noted in the evening during the development and progress of the abscess. There is frequently a quiescent stage of the tuberculous abscess, which is not attended with any rise of temperature. According to its situation and mode of origin, the abscess varies in size from a small cherry to a cavity containing several pints of pus. The shape of the abscess varies; it is usually that of a flattened sphere, but it may present pockets or burrows running in various directions. Sometimes the abscess is hour-glass or dumb-bell shaped; this is well illustrated in the region of the groin in disease of the spine or pelvis, where there may be one large sac occupying the venter ilii, and a smaller one in the thigh, the two communicating by a narrow channel under Poupart's ligament. By pressing with the fingers the pus may be displaced from one compartment to the other. Occasionally the progress of the abscess is arrested, and it may remain stationary for an indefinite period. The usual course of events, however, is that the abscess progresses slowly, and finally reaches a free surface—usually the skin. As it does so there may be some pain, redness, and local elevation of temperature. Fluctuation becomes more and more evident and superficial, and the skin becomes livid and finally gives way. If the case is left to nature, the discharge of pus continues, and the track opening on the skin surface remains as *a sinus*. The persistence of suppuration is due to the presence in the wall of the abscess and of the sinus, of tubercle bacilli and tuberculous granulation tissue, which, so long as they remain, continue to furnish discharge, and so prevent healing. Sooner or later

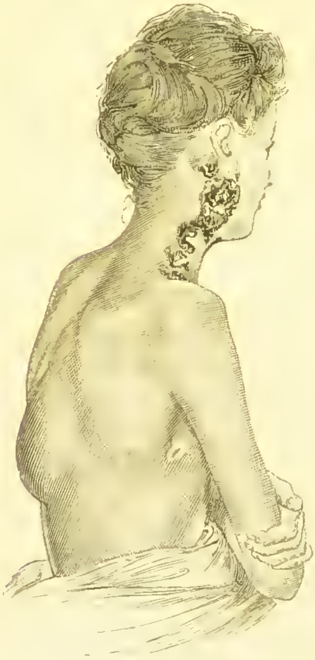

FIG. 26.—A young woman, showing (1) a Cold Abscess of the Back; (2) Tuberculous Ulceration of Skin of Neck subsequent to Disease in the Glands.

pyogenic organisms gain access to the sinus, and through it to the wall of the abscess. They tend further to depress the resisting power of the tissues, and thereby aggravate and perpetuate the tuberculous disease. This superadded infection with pyogenic organisms exposes the patient to the further risks of septic intoxication, especially in the form of hectic fever and septicæmia, and to general tuberculosis. A tuberculous abscess may in one or other of these ways be a cause of death.

The chronic abscess may be met with anywhere in the subcutaneous or other cellular tissue. It is often the result of tuberculous disease in a lymphatic gland, in a bone, or in one or other of the organs of the body, such as the kidney or testicle.

Residual abscess is the name given to the abscess, which may make its appearance months, or even years, after the apparent cure of tuberculous disease—as, for example, in the hip-joint or spine. It is called residual because it has its origin in the residuum or remains of the original disease.

Diagnosis.—The typical cold abscess is to be diagnosed from a softening syphilitic gumma, a cyst, a lipoma, and from other soft tumours. When a tuberculous abscess is about to burst externally, it may be difficult to distinguish it from an abscess due to infection with pyogenic organisms. Help is obtained by the history, and by recognising the association of the abscess with tuberculous disease in one of the organs or tissues in the neighbourhood. Even when the abscess is opened, the appearances of the pus may not supply the desired information, and it may be necessary to submit it to bacteriological examination or experimental inoculation in order to arrive at an accurate diagnosis. It may be only after opening the abscess that its seat of origin can be recognised.

Treatment.—It is instructive to know that before the introduction of Listerian methods, surgeons deprecated the opening of tuberculous abscesses because of the almost inevitable occurrence of pyogenic infection, and of the risks which this implies. After the introduction of antiseptics, it became possible to open such abscesses without these risks, and the procedure employed was to make an opening in a dependent position, and secure drainage by means of a rubber tube. The usual result was that the abscess continued to discharge, often for long periods, and the track of the tube frequently became a persistent sinus. The more recent and more successful treatment consists in destroying the wall of the abscess, for in it is contained the tuberculous infection which is the cause both of the abscess and of the persistence of discharge after it has been opened. This is carried out in various ways, according to the situation and extent of the abscess.

We shall consider in the first place the various procedures employed when the skin over the abscess is intact. Theoretically the most certain measure is to *excise the abscess as a whole*, as if it were a tumour; but in practice this is only possible in the small subcutaneous abscesses or strumous nodes met with in children.

Evacuation of the Abscess and Injection of Iodoform.—The preparation employed is a ten per cent. emulsion of powdered iodoform in glycerin, which becomes sterile soon after it is prepared. Its curative effects would appear to depend upon the liberation of iodine, which restrains the activity of the bacilli, and upon its capacity for irritating the tissues and stimulating the formation of scar tissue. An anæsthetic is rarely called for, except in children. The contents of the abscess are first evacuated by means of a large trocar and cannula introduced obliquely through the overlying soft parts, avoiding any part where the skin is thin or red. If the cannula becomes blocked with caseous material it must be cleared with a probe. The iodoform emulsion is injected by means of a glass-barrelled syringe, which should be firmly screwed on to the cannula. The amount injected varies with the size of the abscess and the age of the patient; it may be said to range from two or three drams in the case of children to several ounces in larger abscesses in adults. The cannula is then withdrawn, and the puncture covered with a gauze dressing, and bandaged so as to exert a certain amount of compression. If the abscess fills up again, the injection should be repeated once or oftener. A one per cent. solution of formalin in glycerin has been employed as a substitute for iodoform.

When the contents of the abscess are semi-solid and cannot be evacuated even through a large cannula, a small incision must be made, and after emptying the cavity, the iodoform emulsion is introduced through a short rubber tube attached to the syringe. The injection is continued while the wound is being closed with sutures, so that when the operation is completed the cavity will be distended with the emulsion. The method is not satisfactory unless the wound heals by first intention. Experience has shown that even large abscesses, such as those associated with spinal disease, may be cured by one or other of the above methods of iodoform injection.

Another method of treatment is by *incision of the abscess and removal of the tuberculous tissue in its wall* with the sharp spoon. An incision is made which will give free access to the interior of the abscess; otherwise outlying pockets or recesses are liable to be overlooked. Small incisions are only justifiable when an extensive scar would be disfiguring. After removing the pus the walls of the abscess are thoroughly scraped with the ordinary Volkmann spoon or with Barker's flushing spoon, to get rid of the tuberculous granulation tissue with which they are lined. In using the spoon care must be taken that its sharp edge does not perforate the wall of a vein or other important structure. Any debris which may adhere to the walls is easily removed by rubbing with dry gauze. The oozing of blood from the raw surface left after scraping is arrested by packing the cavity for a few minutes with gauze. After removing the packing, the walls are painted with pure carbolic acid, or iodoform powder may be rubbed into the raw surface. If the abscess is so situated that its cavity can be obliterated by pressure, and if there is no suspicion of septic infection, the wound may be stitched up. If, on the other hand, there is fear of a mixed infection, it is safer to treat it by the open method, packing the cavity with iodoform worsted, which is renewed at intervals as the cavity heals up from the bottom.

When the skin over the abscess is red, thin, and about to give way, as is frequently the case when the abscess is situated in the subcutaneous cellular tissue, any portion which is obviously infected with tubercle should be removed with the scissors at the same time that the abscess is incised.

In abscesses treated by the open method, when the cavity has become lined with healthy granulations, it may be closed by secondary sutures, or, if the granulating surface is flush with the skin, healing may be hastened by skin-grafting.

If the tuberculous abscess does not come under treatment until after it has burst and left a sinus, the procedure will depend on whether or not the sinus has become infected with pyogenic organisms. If not infected, it may be treated with iodoform emulsion; an olive-shaped nozzle is attached to the syringe, so that the orifice of the sinus may be closed and prevent the immediate escape of the emulsion, which must be forced into the sinus; the nozzle is withdrawn, and the orifice closed with the finger for ten minutes; it will then be found that only a little clear glycerine escapes; pads of gauze are then applied. The procedure is repeated two or three times a week.

Septic sinuses are better laid open, scraped, disinfected, and made to heal from the bottom by the open method. It would appear that exposure to the X-rays may prove of value in the treatment of tuberculous sinuses.

In the treatment of a tuberculous abscess it is always necessary to search for any associated disease such as may be found in a lymphatic gland or bone, and to this, treatment must also be directed.

The *tuberculous ulcer* has been described in the chapter on Ulcers.

CHAPTER X.

SYPHILIS.

Definition.—ACQUIRED SYPHILIS—Primary period: *Incubation, primary chancre, glandular enlargement, extra-genital chancres*—Treatment—Secondary period: *General symptoms, skin affections, mucous patches, affections of bones, joints, eyes, etc.*—Treatment: *Methods of administering mercury*—Syphilis and marriage—Intermediate stage—*Reminders*—Tertiary period: *General symptoms, gummata, tertiary ulcers, tertiary lesions of skin, mucous membrane, bones, joints, etc.*—Second attacks.—INHERITED SYPHILIS—Transmission—*Clinical features in infancy, in later life*—Contagiousness—Treatment.

SYPHILIS is an infective disease due to the entrance into the body of a virus, the nature of which has not yet been definitely ascertained. It is nearly always communicated from one individual to another by contact infection, the discharge from a syphilitic lesion being the medium through which the virus is transmitted.

It belongs to the group of diseases known as the infective granulomata, a group which includes tuberculosis, actinomycosis, glanders, and leprosy. Syphilis may be described as a chronic inflammation attended with the formation of granulation tissue which has certain structural peculiarities and degenerative tendencies. Syphilitic granulation tissue is made up of round cells, epithelioid cells, and giant cells, so like those met with in tuberculous lesions that a differential diagnosis based on histological structure alone cannot be relied upon. It may be possible, however, to distinguish syphilitic from tuberculous granulation tissue by demonstrating tubercle bacilli in the latter.

When syphilis is communicated from one individual to another by contact infection, the first visible sign of the disease appears at the site of inoculation, and is known as *the primary sore*. The disease is then spoken of as acquired syphilis. Individuals who have acquired the disease may transmit it to their offspring, who are then said to suffer from *inherited syphilis.* In the inherited disease there is no primary sore. The virus being disseminated throughout the body from the outset, the clinical manifestations are entirely constitutional.

ACQUIRED SYPHILIS.

In the vast majority of cases infection takes place during the congress of the sexes. Delicate, easily-abraded surfaces are then brought into contact, and the discharge from lesions containing the virus is placed under favourable conditions for conveying the disease from one person to the other. In the male the possibility of infection taking place is increased if the virus is retained under cover of a long and tight prepuce, and if there be abrasions on the surface with which it comes in contact. The frequency with which infection takes place on the external genitals during sexual intercourse warrants syphilis being considered a venereal disease, although there are other ways in which it may be contracted.

Some of these imply direct contact—such, for example, as kissing, the digital examination of syphilitic patients by doctors or nurses, or infection of the surgeon's fingers while operating upon a syphilitic patient. In suckling, a syphilitic wet nurse may infect a healthy infant, or a syphilitic infant may infect a healthy wet nurse. In other cases the infection is by indirect contact, the virus being conveyed through the medium of articles contaminated by a syphilitic patient—such, for example, as surgical instruments, tobacco pipes, wind instruments, table utensils, towels, or underclothing. Physiological secretions, such as saliva, milk, or tears, are not capable of communicating the disease unless contaminated by discharge from a syphilitic sore. While the saliva itself is innocuous, it can be and often is contaminated by the discharge from mucous patches or other syphilitic lesions in the mouth and throat, and is then a dangerous source of infection. Unless these extra-genital sources of infection are borne in mind, there is a danger of failing to recognise the primary sore of syphilis in unusual positions, such as the lip, finger, or nipple.

Stages or Periods of Syphilis.—Following the teaching of Ricord, it is customary to subdivide the life-history of syphilis into three periods or stages, referred to, for convenience, as primary, secondary, and tertiary. This subdivision is to some extent arbitrary and artificial, as the different stages overlap one another, and the lesions of one stage merge insensibly into those of another. The primary stage is the only one which is constant as regards its local appearances and general symptoms. Wide variations are met with in the clinical manifestations of the secondary stage, and histologically there is no valid distinction to be drawn between the lesions of the secondary and tertiary stages.

The primary period embraces the interval which elapses between the initial infection and the first constitutional manifestations,—roughly from four to eight weeks,—and includes the period of incubation, the development of the primary sore, and the enlargement of the nearest lymphatic glands.

The secondary period varies in duration from one to two years, during which time the patient is liable to suffer from constitutional manifestations which are for the most part superficial in character, affecting the skin and its appendages, the mucous membranes, and the lymphatic glands.

The tertiary period has no time limit except that it follows upon the secondary, so that during the remainder of his life the patient is liable to suffer from constitutional manifestations which may affect the deeper tissues and internal organs as well as the skin and mucous membranes.

Primary Syphilis.—*The period of incubation* represents the interval which elapses between the occurrence of infection and the appearance of the primary sore at the site of inoculation. Its limits may be stated as varying from two to six weeks, with an average of from twenty-one to twenty-eight days. While the disease is incubating, the patient retains his usual health and is quite unconscious of having contracted any disease.

The Primary Sore.—The incubation period having elapsed, there appears at the site of inoculation a circumscribed area of inflammation, which in time becomes indurated, and which may or may not be attended with ulceration. The first appearance is that of a slight elevation or papule which, as it increases in size, presents a smooth and shiny surface. In the course of a week or ten days it usually becomes a circular or oval, sharply-defined sore, rarely larger than a quarter of an inch in diameter. The sore has an elevated border, a depressed centre, and an indurated base, and exudes a scanty, thin, watery discharge. As a rule the patient suffers little or no discomfort, and may even be ignorant of the existence of a sore, unless it has been exposed to septic or mechanical irritation, in which case the ulceration may become a more prominent feature, the sore being more sensitive and yielding a sero-purulent discharge. It cannot be emphasised too strongly that the induration at the base of the sore, which has obtained for it the name of hard chancre, is its most important clinical characteristic. The induration is best appreciated when the sore is grasped from side to side between the finger and thumb. It is usually well defined, and greater in extent than the sore itself. The sensation on grasping it has been aptly compared to that imparted by a nodule of cartilage, or by a button felt through a layer of cloth. The evidence obtained by touching the sore is more valuable than that obtained by inspection, a fact which is made use of in the recognition of concealed chancres—that is, those which are hidden from view by a tight prepuce. The induration is due not only to the dense packing of the connective-tissue spaces with small round cells, but to the formation of new connective-tissue elements. It is a gradual process and may not attain its maximum until the healing of the sore is well advanced, and it may persist long after the ulcer has healed. It is most marked in the male in relation to chancres situated in the furrow between the glans penis and the prepuce.

In the male the following are the most frequent *situations* of the primary sore :—(1) On the inner aspect of the prepuce, and in the fold between the prepuce and the glans; in the latter situation the induration imparts a "collar-like" rigidity to the prepuce which is most apparent when it is rolled back over the corona. (2) At the orifice of the prepuce, in which situation it often leads to a certain degree of phimosis. (3) On the corona of the glans. (4) On the external aspect of the prepuce or on the skin of the penis itself. (5) In relation to the meatus and canal of the urethra, in either of which situations the swelling and induration may lead to narrowing of the urethra, so that the urine is passed with pain and difficulty and in a very minute stream. A chancre in the canal of the urethra is very rare, and being concealed from view its existence is recognised by the discharge from the meatus and by the induration felt between the finger and thumb.

In the female the primary sore is usually met with on the labia, and as the induration is rarely characteristic and does not last so long as in the male, its existence is liable to be overlooked. Primary syphilis is much less common in women than in men, as from the circumstances of prostitution one woman is capable of infecting a number of men.

The hard chancre is usually solitary, but cases are met with in which there are two or more. In all cases of multiple chancre it may be safely assumed that they are the result of inoculation of the virus at several points,—either simultaneously or within a day or two of each other,—because once a chancre has reached the stage of induration it is no longer possible to produce other chancres by any subsequent inoculation.

The duration of the hard chancre depends very much upon whether it is treated or not. In cases left to nature it may persist for many weeks, and may still be recognisable when, at a later period, constitutional symptoms make their appearance.

The formation of a visible scar is rather the exception than the rule. Unless the sore has been irritated and has partaken of the character of an open ulcer with purulent discharge, or has sloughed, there is no permanent scar; hence in examining patients with a doubtful history of syphilis, little reliance can be placed on the presence or absence of a scar on the penis.

Infection of the adjacent lymphatic vessels and glands is usually found to have taken place by the time the primary sore has acquired its characteristic induration. Several of the glands along Poupart's ligament, on one or on both sides, become enlarged and indurated; they are rarely sensitive unless the primary sore is inflamed. As when palpated they feel like shot under the skin, the term *bullet-bubo* has been applied to them. The glands remain freely movable, and the enlargement and induration usually persist after the sore has healed. Their presence may be useful in clearing up the diagnosis in cases where the primary sore has been atypical or has been overlooked. They never undergo suppuration unless pyogenic infection be superadded. The lymphatic vessels on the dorsum of the penis proceeding from the sore to the affected glands may participate in the induration, and may be felt as fine cords beneath the skin.

Phagedæna as a complication of primary syphilis is really a form of moist gangrene, due to a local septic infection and attended with rapid destruction of tissue. It is most frequently met with as a complication of concealed chancres, especially those which are situated far back under a tight prepuce. A foul-smelling, blood-stained discharge escapes from the preputial orifice; there may be a good deal of pain, and the patient is ill and out of sorts. The prepuce on one aspect may become of a dusky red or bluish colour and finally slough, exposing the glans. The loss of tissue may be limited to the prepuce or may involve the glans and body of the penis, and hæmorrhage may occur from the erosion of the walls of blood-vessels. An interesting fact in relation to phagedæna is the frequent immunity of the adjacent lymphatic glands—that is to say, there is rarely any bubo, and there may be no subsequent manifestations of constitutional syphilis.

Diagnosis.—The differential diagnosis necessitates the consideration of the *soft sore*, *soft chancre*, or *chancroid*, which is also a common form of venereal disease, especially in men. It has nothing to do with syphilis, only it occurs in the same situation as the hard sore, and is acquired in the same way. Soft sores are always contracted by direct contact from another individual. There is reason to believe that women may be the carriers of the poison without themselves actually suffering from soft sores. They belong to the class of septic diseases, and result from infection with a virulent pus-forming bacillus, first described by Ducrey. The incubation period is a short one of from two to five days. The sores are most often situated in the vicinity of the frænum of the prepuce. They commence as pustules which aro rapidly converted into small, acutely-inflamed ulcers with sharply-cut, irregular margins, and an abundant yellow purulent discharge. They are devoid of the characteristic induration of syphilis ; they are painful and nearly always multiple, reproducing themselves in successive crops by auto-inoculation. Soft sores are frequently complicated with phimosis and balanitis, and occasionally with phagedæna. They frequently lead to infection of the glands in the groin, and the resulting bubo is very different from that associated with primary syphilis. It is ill-defined, painful, and very tender; the overlying skin which is infiltrated becomes adherent and red, and suppuration takes place either in the form of separate foci in the interior of the individual glands, or around them, so that on incision the glands may be found lying bathed in pus. If the suppuration is left to nature it may cause considerable undermining of the skin before the pus bursts externally. The buboes associated with soft sore are probably the result of infection with the same bacillus as is found in the sore itself.

Soft sores heal rapidly when kept thoroughly clean. They may be touched with bluestone or lightly dusted with a powder consisting of one part iodoform and three parts boracic acid. The sore is then covered with a gauze dressing kept in position by drawing the prepuce over it, or by a few turns of a narrow bandage or strip of plaster. If the sores tend to spread or to give rise to fresh ones in their vicinity, they should be touched with pure carbolic acid. If there is phimosis with balanitis, the prepuce must either be washed out at frequent intervals or removed by circumcision ; in the latter case bluestone should be rubbed into the raw surface made at the operation. When the glands in the groin become inflamed the patient must be confined to bed and a carbolic or lead and opium fomentation applied. When suppuration takes place, the pus must be evacuated by one or more incisions parallel to Poupart's ligament, undermined skin must be cut away, and if the glands are found lying exposed in the abscess cavity they should be removed. The cavity is scrubbed out with pure carbolic acid and lightly packed with iodoform worsted. The results of operations for the complete removal of the glands have not been altogether satisfactory.

It is important to bear in mind the possibility of a patient having acquired a mixed infection—the virus of the soft chancre, which will manifest itself a few days after infection, and the virus of syphilis, which will show itself after an interval of several weeks. This occurrence was formerly the source of much confusion in diagnosis, and it was believed at one time that syphilis might result from soft sores, but we now know that syphilis does not follow upon soft sores unless the virus of syphilis has been introduced at the same time. The practitioner must be on his guard, therefore, when a patient asks his advice concerning a venereal sore which has appeared within a few days of exposure to infection. Such a patient is naturally anxious to know whether he has contracted syphilis or not, but neither a positive nor a negative answer can be given until the incubation period of syphilis has elapsed—that is, not until after an interval of four or five weeks.

In typical cases where there is a clear history of an incubation period of three to five weeks since infection, when the sore is indurated, persistent, and indolent, and is attended with bullet-buboes in the groin, the diagnosis of primary syphilis is not difficult. Apprehensive patients who have committed sexual indiscretions are apt to regard as syphilitic any lesion which happens to be located on the penis—for example, acne pustules, eczema, psoriasis papules, boils, balanitis, herpes, and warts. Syphilis is also to be diagnosed from epithelioma, the common form of cancer of the penis. It is especially in elderly patients with a tight prepuce that one is liable to mistake the induration of epithelioma for that associated with syphilis. In difficult cases the prepuce must be slit open, or the patient kept under observation until the effects of treatment can be ascertained; the chancre readily yields to anti-syphilitic remedies while the epithelioma progresses until its cancerous nature is no longer open to doubt.

Extra-genital or Erratic Chancres.—Erratic chancre is the term applied by Jonathan Hutchinson to the primary sore of syphilis when it appears on other parts of the body than the genital organs. It is scarcely possible to mention any part of the body on which these have not been observed. They differ to some extent from the hard sore as met with on the penis. The sore is usually larger, with more inflammation and pain, and less definite induration, and the associated bubo is very much larger and more sensitive. The bubo affects the glands in nearest relation to the sore, so that we look for enlargement of the epitrochlear or axillary glands in chancre of the finger, of the submaxillary glands in chancre of the lip or mouth, or of the pre-auricular gland in chancre of the eyelid or forehead. In consequence of their divergence from the typical chancre and of their being often met with in individuals who, from age, surroundings, or moral character, are unlikely subjects of venereal disease, the true nature of erratic chancres is often overlooked until the persistence of the lesion, its want of resemblance to anything else, or the onset of constitutional symptoms determines the diagnosis of syphilis. A solitary, indolent sore occurring on the lip, eyelid, finger, or nipple, which does not heal but tends to increase in size, and is associated with induration and enlargement of the adjacent glands, is most likely to be the primary sore of syphilis. The erratic chancre may become the seat of phagedæna.

The prognosis in primary syphilis should always be given with reserve. In the absence of treatment, constitutional symptoms will follow with very few exceptions; but if the patient is brought under the influence of mercury, although constitutional symptoms may not fail to show themselves they will be greatly modified.

Treatment.—Reference may be made in the first instance to the question of excising or destroying the primary sore with a view to the prevention of constitutional infection. As a matter of fact, this question very rarely arises in practice, because by the time the chancre has sufficiently developed to be diagnosed with certainty, the virus has already entered the lymphatics, and is beyond the reach of surgical interference. When the chancre is situated on the prepuce it may be an advantage to remove it by performing circumcision, without, however, holding out any certain hope of preventing constitutional infection. So long as the diagnosis is uncertain, treatment should be restricted to keeping the suspected sore absolutely clean, .and to protecting it from irritation. When the diagnosis of syphilis is established, the question arises whether or not the patient should be brought under the influence of mercury. While condemning the institution of what must necessarily be a prolonged course of mercury in the case of doubtful sores, we agree with those who, regarding mercury as the best-known antidote to the virus of syphilis, aim at bringing the patient under the influence of the drug before the disease has become generalised. It is a significant fact that those who maintain that mercury should be withheld until the appearance of constitutional symptoms, are in the habit of giving the drug in spreading chancres with phagedæna, in those situated where the loss of tissue may do serious harm—as, for example, on the eyelid, and in married people, and in the case of chancres on the fingers, where there is a special risk of infecting others. The natural inference is, that if it is beneficial in these cases it is capable of doing good in all. In the presence of a chancre with well-defined induration and bullet-buboes, therefore, we prescribe mercury. The methods of administering the drug will be described with the treatment of secondary syphilis.

The local treatment of the primary sore is chiefly concerned with the maintenance of absolute cleanliness. The part is washed night and morning, preferably with boracic lotion; if the surface is unbroken, it may be dusted lightly with a powder composed of equal parts of calomel and carbonate of zinc. If there is an ulcer, the traditional and efficient application is that of a piece of lint or gauze soaked in black wash, renewed night and morning, or oftener if there is much discharge, and kept in place either by drawing the prepuce over it or by a few turns of narrow bandage or plaster. If there is any superadded inflammation or œdema the patient should be confined to bed.

In concealed chancres with phimosis the sac of the prepuce should be frequently washed out with boracic or weak sublimate lotion or peroxide of hydrogen, by means of a syringe. If, however, the discharge which escapes from under the prepuce becomes foul and blood-stained, as in phagedæna, the prepuce should be slit open along the dorsum, or if sloughing, it should be cut away. The patient must sit frequently in a hot bath of weak sublimate lotion; in the intervals the parts are dressed with black wash or a powder of iodoform and calomel. If the gangrene tends to spread, the patient should be anæsthetised, the infected tissues removed with the scissors and spoon, and the raw surface rubbed with pure carbolic acid or the acid nitrate of mercury, followed by dusting with calomel and iodoform powder. When the chancre is within the meatus, iodoform bougies are inserted into the urethra, and the urine should be rendered bland by drinking large quantities of fluid; although the stream may become very small, retention is almost unknown, and the patient need have little fear of a stricture in the future.

Secondary Syphilis.—The following description of secondary syphilis is based on the average course of the disease as observed in patients who are not treated with mercury. The onset of constitutional symptoms occurs from two to three months after the original infection, and the manifestations are to be regarded as the result of the entrance of the virus into the general circulation, so that it is carried to all parts of the body. The period during which the patient is liable to suffer from secondary symptoms varies indefinitely, but may be stated generally as being from six months to two years.

In some cases the general health of the patient is not disturbed; in others he is feverish and out of sorts, loses appetite, becomes pale and anæmic, complains of lassitude, incapacity for exertion, headache, and pains in the bones, especially at night. There is usually a marked degree of leucocytosis. The lymphatic glands accessible to palpation, such as those in the neck, axilla, and at the elbow, become enlarged and slightly tender. The hair comes out, and eruptions appear on the skin and mucous membranes. Sore throat and certain affections of the eyes are common.

The Skin Affections are among the earliest and most constant evidences of secondary syphilis. Individually they resemble similar eruptions from other causes, and present no single characteristic feature by which their origin may be recognised. Syphilis does, however, impress upon them certain general characters, which, taken collectively, stamp them as "specific." Thus they are frequently, and sometimes to a marked degree, symmetrical; several types of eruption may be present at the same time; there is little itching or discomfort so that unobservant patients may not be aware of their existence; they usually present a serpiginous outline and a dull-red or coppery coloration which has been likened to that of the lean of raw ham; they exhibit a predilection for the flexor aspects of the limbs, and for those parts of the forehead and neck which are close to the roots of the hair; they tend to pass off spontaneously, especially the earlier ones; and they disappear rapidly under treatment by mercury.

Varieties of Syphilitic Skin Eruptions.—*Roseola* is one of the commonest of the early rashes, and, being merely a hyperæmia or congestion of the skin, is usually very evanescent. It assumes the form of small circular spots or macules of a dusky rose colour not unlike the eruption of measles, and as

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it fades leaves a brownish coloration or stain which in time disappears.

Papules.—A papular or lichenoid syphilide may appear in the form of small or large spots which are raised above the skin, and smooth or scaly on the surface. They are due to cellular infiltration of the skin. They develop gradually, and may persist for several weeks, leaving brownish pigmented areas which are very characteristic. On the palms of the hands and soles of the feet the papules may be so numerous and so scaly as to merit the term psoriasis; but as ordinary psoriasis scarcely ever occurs in these situations, this eruption is very suggestive of syphilis.

The other types of eruption are rarer in comparison, and usually occur at a later stage of the disease. *A pustular syphilide*, resembling acne or chicken-pox, may be met with, but, unless from its distribution, or its association with the remains of the papular eruption already described, it is not characteristic. *A nodular or tubercular syphilide* is chiefly met with on the face and scrotum; it begins as closely-packed nodules which break down, forming superficial ulcers, and as these may heal in the centre while spreading at the margin, often in a serpiginous manner, the lesion may resemble lupus of tuberculous origin. It is extremely chronic, and tends to relapse. The lesions to which the names *pemphigus* and *rupia* are applied are rare, and as they occur late in the disease are sometimes classed with the tertiary manifestations. They are chiefly met with in severe attacks of syphilis in patients who are broken down in health. Rupia starts as a bulla or blister of which the contents dry up and leave a scab, beneath which there forms an ulcer, which extends both in area and in depth; the scab becomes thick, raised above the surface, dark in colour, and assumes a conical shape, roughly resembling the shell of a limpet. If the scab is detached, the ulcer is exposed. Rupia is very persistent, and finally leaves scars which tend to be circular, thin, supple, of a white colour, and with a pigmented margin.

Condylomata are probably more characteristic of constitutional syphilis than any other single type of skin eruption. They are simply large scaly papules occurring on those parts of the body where the skin is habitually moist, and especially where two skin surfaces are in contact. They are chiefly met with in relation to the external genitals, especially in women, around the anus, beneath large pendulous mammæ, between the toes, and at the angles of the mouth, and in these situations their development is greatly favoured by neglect of ordinary cleanliness. Condylomata present the appearance of well-defined circular or ovoid areas in which the skin is thickened and raised above the surface; they are covered with a white sodden epidermis, and furnish a scanty but very infective discharge. Under the influence of irritation and want of rest, as at the anus, or angle of the mouth, they are apt to become fissured and superficially ulcerated, and the discharge then becomes more abundant, and may crust on the surface, forming yellow scabs. At the angle of the mouth the condylomatous patches may spread from the edge of the mucous membrane on to the skin of the cheek, and when they ulcerate may leave numerous fissure-like scars radiating from the mouth—an appearance best seen in inherited syphilis.

The Appendages of the Skin.—The *hair* loses its gloss, becomes dry and brittle and readily falls out, either as an exaggeration of the normal shedding of the hair or in scattered areas over the scalp. In young adults it is usually reproduced, but in older patients, or where the scalp has been the seat of a severe pustular eruption, the hair which is lost may not be replaced. *The nails* of the fingers and toes occasionally present a troublesome pustular eruption and superficial ulceration around their margins, to which the name *syphilitic onychia* has been applied; more commonly the nails become brittle and ragged, and they may even be shed altogether.

The Mucous Membranes, and especially those of *the mouth* and *throat*, suffer from lesions similar to those met with on the skin. From the discomfort which they produce they are more likely to attract the attention of the patient, so that in the diagnosis of antecedent syphilis the history of a sore mouth or throat may be of considerable assistance. On a mucous surface the papular eruption assumes the form of *mucous patches*, which are areas with a congested base covered with a thin white film of sodden epithelium like wet tissue-paper. They are best seen on the inner aspect of the cheeks, the soft palate, uvula, pillars of the fauces and tonsils. In addition to mucous patches, there may be a number of small, superficial, kidney-shaped ulcers, especially along the margins of the tongue and on the tonsils. In the *larynx* the presence of congestion, œdema, and mucous patches may be the cause of persistent hoarseness. The *tongue* often presents a combination of lesions including ulcers, patches where the papillæ are absent, fissures, and raised white papules resembling warts, especially towards the centre of the dorsum. These lesions are specially apt to occur in those who smoke, drink, and eat hot condiments to excess, and in those with irregular, sharp-cornered teeth. At a later period, and in those who are broken down in health from intemperance or other causes, a more serious form of ulceration may be met with in the throat similar to that occurring in the skin. Rapidly-spreading, penetrating ulcers, almost phagedænic in character, may make their appearance on the soft palate and pillars of the fauces, and may lead to great destruction of tissue and subsequent deformity.

In the bones there may be congestive lesions analogous to those met with in the skin and mucous membranes, which assume the clinical features of an evanescent periostitis, the patient complaining of nocturnal pains over the frontal bone, sternum, tibiæ and ulnæ, and localised tenderness on tapping over these bones. These lesions never suppurate, and usually disappear without leaving any trace of their existence; they may, however, result in localised periosteal thickenings or nodes which remain painful and tender on pressure. They readily yield to antisyphilitic treatment.

The patient may complain of pain and sensitiveness in one or more joints without there being any visible organic changes to account for them; or a condition of serous synovitis or hydrops, sometimes called syphilitic rheumatism, may ensue. This is chiefly met with in the knee, and may be bilateral.

The Affections of the Eyes, although fortunately rare, are of great importance because of the serious results which may follow if they are not recognised and treated. *Iritis* is the commonest of these, and may occur in one or in both eyes, one after the other, from three to eight months after infection. The patient complains of impairment of sight and discomfort in the eye, and of frontal or supraorbital pain. The eye waters and is hypersensitive to light, the iris is discoloured and reacts sluggishly, and there is a zone of ciliary congestion around the cornea. The appearance of minute white nodules or flakes of lymph at the margin of the pupil is especially characteristic of syphilitic iritis. When adhesions have formed between the iris and the structures in relation to it, the pupil dilates irregularly under atropin. Although complete recovery is to be expected under early and energetic treatment, if neglected, *iritis* may result in occlusion of the pupil and permanent impairment or loss of sight.

The other lesions of the eye are much rarer, and can only be discovered on ophthalmoscopic examination. *Choroiditis* occurs in patches, and leaves areas of a white or grey colour surrounded by black pigment. Unless these patches occur in the vicinity of the optic disc they give rise to no symptoms. *Neuro-retinitis*, on the other hand, attracts attention because it is attended with rapid failure of sight in one or in both eyes; the optic disc and adjacent retina present the usual appearances of inflammation, becoming blurred and hazy.

In the arteries of the Brain, in the later periods of secondary, and in tertiary syphilis, changes of the nature of *endarteritis*, attended with narrowing of their lumen, and it may be complete obliteration from superadded thrombosis, are met with. By interfering with the nutrition of those parts of the brain to which the affected arteries are distributed, these lesions give rise to clinical features of which severe headache and paralysis are the most prominent. The paralysis may involve one side of the body (hemiplegia), and be attended with convulsions and coma, or may be confined to one limb or to the area of distribution of certain of the cranial nerves. Anti-syphilitic remedies have but little curative influence in these vascular lesions, and the paralysis is often permanent.

Affections of the spinal cord are extremely rare, but paraplegia from myelitis has been observed in isolated instances.

Attention must be directed to the remarkable variation which is observed in the severity of the symptoms in different individuals. While some patients, and especially women, may be scarcely aware that they are the subjects of secondary syphilis, others, and fortunately the minority, suffer from one lesion after another until their general health entirely breaks down.

Treatment of Secondary Syphilis.—There is practical unanimity in regarding mercury as the only specific remedy or antidote for syphilis, and it has already been pointed out in relation to the primary stage, that as soon as the diagnosis is certain the patient should be brought under the influence of this drug. The quantity of mercury given must be in proportion to the amount and activity of the virus present as evidenced by the symptoms, and with due consideration to the peculiarities of the patient.

Methods of Administering Mercury.—(1) *By the Mouth.*—This has long been the most popular method in this country, the preparation usually employed being grey powder, in pills or tablets, each of which contains one grain of the powder. Three of these are given daily in the first instance; but if the manifestations do not yield or if fresh symptoms appear, the daily dose may be increased to five or even seven grains. When the mercury has gained the upper hand, the daily dose may be again reduced to three or four grains. We do not agree with those who push the drug until it produces its well-known physiological effects of salivation and soreness of the gums. The mercury must be continued in the tonic doses above mentioned for at least one year, or better for two years, with occasional intermissions of a month during the second year. While under mercurial treatment the majority of patients enjoy the best of health. It is a useful practice to keep a record of the body weight, and if this fall it is advisable to stop the mercury for a time. When the grey powder causes irritation of the bowels, it should be combined with iron in small doses, and, if necessary, with a small amount of opium.

The following is a useful formula :—Hydrarg. c. cret. gr. 1 ; ferri sulph. exsiccat. gr. 1 or 2 ; pulv. ipecac. co. gr. 1.

When the grey powder fails to relieve or does not agree with the patient, some other preparation may be substituted, such as the green iodide of mercury, in doses of quarter or half a grain, gradually raised to one grain three times a day ; or the liquor of the perchloride of mercury in teaspoonful doses.

While taking mercury the patient must pay special attention to the teeth and gums. The teeth must be brushed after every meal, and the mouth and throat rinsed out with a solution of chlorate of potash or alum. If the tongue becomes furred and the breath foul, the gums tender, and the saliva increased in amount, the mercury must be temporarily discontinued.

The patient must lead a regular, healthy life ; alcohol must be given up unless it is required as a food, in which case malt liquors or claret may be allowed at meals. The diet should be simple, and easily digested, and should include a full supply of milk. The patient should avoid catching cold or taxing his energies by any extra exertion ; and he should keep the skin acting freely by frequent baths and by wearing woollen under-clothing. On account of the susceptibility of the mouth and throat, he should give up or minimise the use of tobacco.

(2) *By Inunction.*—Inunction consists in rubbing into the skin an ointment containing mercury, such as the mercurial ointment, made with lanolin instead of lard, and diluted to a third of its officinal strength ; or, as this discolours the linen, an ointment composed of equal parts of 20 per cent. oleate of mercury and lanolin. After a hot bath, a portion of the ointment about the size of a hazel nut is rubbed for fifteen minutes every night, or night and morning, into the skin where it is soft and comparatively free from hairs. Different parts of the body should be selected in rotation, and the most scrupulous cleanliness observed so as to avoid septic irritation of the skin.

Inunction is troublesome, and requires great perseverance and care, but it has the advantage of bringing the patient rapidly under the influence of mercury without irritating the bowels. It is specially valuable in severe forms of syphilis, in phagedænic chancres for example, or in cases where time has been already lost and the patient first seeks advice for an *iritis* or other late lesion; it is also of value in most cases of cerebral syphilis, in syphilis appearing after marriage, and in cases where the symptoms persist in spite of the administration of mercury by the mouth. When the patient suffers from gastric catarrh, and this is aggravated by mercury given by the mouth, recourse may be had to inunction.

(3) *By Intramuscular Injection.*—This consists in introducing the drug by means of a hypodermic syringe into the substance of the gluteal muscles. The skin of the patient, and the instrument must be sterilised. The preparation usually employed is the perchloride of mercury in $\frac{1}{8}$ to $\frac{1}{4}$ gr. doses dissolved in glycerin and water, and the injection is made once or twice a week. This method has been found useful by army surgeons who cannot rely on the men taking pills, and as the injection is only made at intervals of several days, the patient need not be admitted into hospital. Unless, however, the dose is regulated with great accuracy, mercurial poisoning may result, with, it may be, serious consequences.

(4) *The Calomel Vapour Bath* (fumigation), which was formerly much employed in the treatment of cases with persistent skin lesions, has practically been given up.

(5) *The Merco-lint Bib or Apron* is the name given to a felt-like fabric which is fashioned in the shape of a bib and contains finely-divided metallic mercury in its meshes. When worn next the skin the mercury evaporates and is believed to be inhaled by the patient as well as absorbed by the skin. It is not so well adapted for the rapid introduction of mercury into the system as the administration by the mouth or by inunction, but it is a convenient and efficient method of keeping the patient under the influence of the drug for prolonged periods. It may be worn constantly or only during the night. The anterior bib, which is shaped like a chest-protector, may be supplemented by a second one, worn over the back. As the amount of mercury absorbed is liable to vary, the patient should be kept under medical supervision.

Iodides in Secondary Syphilis.—While generally recognised as being of little or no use at the beginning of the secondary stage, iodides are of great value in the treatment of the later manifestations, especially those which approach in character the lesions of the tertiary period and do not yield to mercury alone, such as lesions in the skin, throat, and nervous system. The iodide of potassium or sodium is given in five to fifteen grain doses thriee daily, either in solution along with the bichloride of mercury, or separately in the form of tablets. When iodides are given to a patient who has been taking a course of mercury, their effects must be carefully watched, as the iodides liberate mercury which has accumulated in an insoluble form in the tissues, and salivation may result. After the termination of a twelve months' course of mercury, and when all secondary manifestations have disappeared, French authorities recommend a two to three months' course of the iodides alone.

Treatment of the Local Manifestations.—*The skin lesions* are treated on the same lines as similar eruptions of other origin, by combating septic infection, and the removal of crusts and scabs. As local applications, preparations of mercury are usually selected, notably the ointments of the red oxide of mercury, ammoniated mercury, or oleate of mercury (5 per cent.), or the mercurial plaster as introduced by Unna. In the treatment of condylomata the greatest attention must be paid to cleanliness and dryness. After washing and drying the affected patches, they are dusted with a powder consisting of equal parts of calomel and carbonate of zinc; and opposed skin surfaces, such as the nates or labia, are separated by sublimate wool. In the ulcers of later secondary syphilis, crusts are got rid of in the first instance by the application of a boracic poultice or other form of wet dressing, after which a portion of lint or gauze cut to the size of the ulcer and soaked in black wash is applied and covered with oil-silk. If the ulcer tends to spread in area or in depth, it should be scraped with a sharp spoon, and painted over with pure carbolic acid or the acid nitrate of mercury.

In the lesions of the mouth and throat the best local application is a solution of chromic acid,—ten grains to the ounce,—painted on with a brush once daily or every alternate day. In deep phagedaenic ulcers of the throat the patient should gargle frequently with chlorine water or with perchloride of mercury (1 in 2000); if the ulcer continues to spread it should be painted with the acid nitrate of mercury.

In the treatment of *iritis* the eyes are shaded from the light and completely rested, and atropin is dropped into the eye until the pupil is well dilated, in order to prevent adhesions. If there is much pain a blister may be applied to the temple.

The Relations of Syphilis to Marriage.—Even under the most favourable conditions, no patient should be allowed to marry until fully two years have elapsed after the last secondary manifestation has disappeared. Where there have been no secondary manifestations the two years' limit must date from the original chancre. While marriage may be entered upon under these conditions without risk of the husband infecting the wife, the possibility of his conveying the disease to the offspring cannot be absolutely excluded. It has been recommended as a precautionary measure, to give a further mercurial course of two or three months' duration before marriage. In view of the fact that women who have suffered from syphilis retain the liability to transmit the disease to their offspring much longer than men, the responsibility of permitting them to marry should rarely, if ever, be undertaken.

Intermediate Stage.—After the dying away of the secondary manifestations and before the appearance of tertiary lesions, the patient may present certain symptoms which Hutchinson has called *reminders*. They usually consist of relapses of certain of the affections of the skin, mouth, or throat already described. In the skin, they may assume the form of peeling patches in the palms, or as spreading and confluent circles of a scaly papular eruption, which, if neglected, may lead to the formation of fissures and superficial ulcers. They are easily cured, but readily relapse. Less frequently there may be a relapse of the eye affections, or of the paralytic symptoms from disease of the cerebral arteries.

Treatment is conducted on the same lines as in late secondary syphilis, mercury and iodides being given in combination. Sometimes the preparation known as Donovan's solution, containing the double iodide of mercury and arsenic, is to be preferred. The general health usually requires to be built up by tonics and change of air, and a sea voyage may be found of the greatest value in increasing the resisting powers of the patient.

Tertiary Syphilis. — Although the early and systematic treatment of syphilis by mercury nearly always prevents the manifestations which fall to be described under this head, it is impossible to give a guarantee to this effect in any individual case. While the manifestations of primary and secondary syphilis are common enough in practice, those of the tertiary period are by comparison rare, and are chiefly observed in those who have either neglected treatment or who have had their powers of resistance lowered by privation, by alcoholic indulgence, or by prolonged residence in tropical climates.

The general characters of tertiary manifestations may be stated as follows. They attack by preference the tissues derived from the mesoblastic layer of the embryo, the cellular tissue, bones, muscles, and viscera. They are often localised to one particular tissue or organ—such, for example, as the subcutaneous cellular tissue, the bones, or the liver, and they are rarely symmetrical. They are usually aggressive and persistent, with little tendency to natural cure. They are the only syphilitic lesions which may be dangerous to life, because of the destructive changes produced in such organs as the brain or the larynx. They are remarkably amenable to treatment by iodides, if these are given before that stage is reached which is attended with destruction of tissue. Early tertiary lesions may be infective, and the disease may be transmitted by the discharges from them; but the later the lesions are of appearing the less is the risk of their containing an infective virus. The most prominent feature of tertiary syphilis consists in the formation of granulation tissue, and this takes place on a scale considerably larger than that observed in lesions of the secondary period. The granulation tissue frequently forms a definite swelling or tumour-like mass (syphiloma), which, from its peculiar elastic consistence, is known as a *gumma.* The gumma does harm by displacing and replacing the normal tissue elements of the part affected, and by involving these in the degenerative changes of the nature of caseation and necrosis which it is liable to undergo, and which result in the well-known destructive lesions of the skin, mucous membranes, and internal organs. This is true not only of the circumscribed mass or gumma, but of the condition in which the granulation tissue is diffused throughout the connective-tissue framework of such an organ as the tongue or liver, and which is known as *gummatous infiltration* or syphilitic cirrhosis.

The life-history of an untreated gumma varies with its environment. When protected from injury and irritation in the substance of an internal organ such as the liver, it may become encapsulated by fibrous tissue and persist in this condition for an indefinite period, or it may become absorbed and leave in its place a fibrous cicatrix. In the interior of a long bone it may replace the rigid framework of the shaft to such an extent as to lead to pathological fracture. If it is near the surface of the body,—as, for example, in the subcutaneous or submucous cellular tissue, or in the periosteum of a superficial bone, such as the palate,—the skull (Fig. 31), or the tibia, the tissue of which it is composed is very apt to undergo necrosis in which the overlying skin or mucous membrane frequently participates, the result being an ulcer—the tertiary syphilitic ulcer (Fig. 27).

Tertiary Lesions of the Skin and Subcutaneous Cellular Tissue.—The clinical features of a *subcutaneous gumma* are those of an indolent, painless, elastic swelling, varying in size from a pea to that of an almond or walnut. After a variable period it usually softens in the centre, the skin over it becomes livid and dusky, and finally separates as a slough, exposing the tissue of the gumma beneath. Sometimes this appears as a mucoid, yellowish, honey-like substance; more frequently as a sodden, caseated tissue resembling wash leather. Unlike the contents of a tuberculous abscess, the degenerated tissue of a gumma is only gradually separated, and may be visible for weeks in the floor of the ulcer. The caseated tissue of a gumma differs from the corresponding tissue of a tuberculous lesion in being tough and firm, of a buff colour like wash leather, or whitish, like boiled fish. According to the extent of skin which has sloughed over a gumma, the resulting defect may be described as a sinus or as an ulcer.

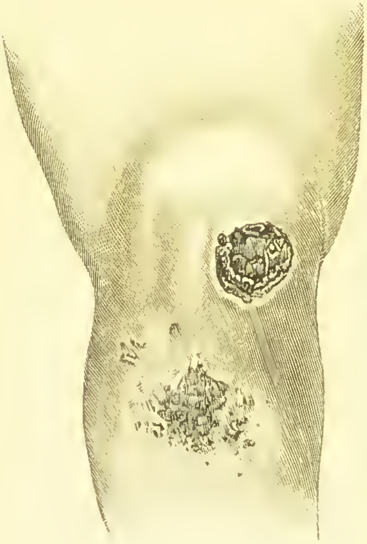

Fig. 27.—Tertiary Syphilitic Ulceration in region of Knee in woman æt. 35.

The tertiary ulcer may be situated anywhere, but is most frequently met with on the legs, especially in the region of the knee (Fig. 27) and over the calf. There may be one or more ulcers, and there may be scars of antecedent ulcers. The edges are sharply cut, as if punched out; the margins are rounded in outline, firm, and congested; the base is occupied by gummatous tissue, or, if this has already separated and sloughed out, by unhealthy granulations and a thick purulent discharge. In rare cases the ulcer spreads by a destructive process allied to phagedæna. When the ulcer has healed, it leaves a scar which may or may not be depressed, but is usually thin, supple, and white in the centre with a pigmented margin. The features of the tertiary ulcer, however, are not always so characteristic as the above description would imply. It is to be diagnosed from the "leg ulcer" which occurs almost exclusively on the lower third of the leg; from a form of chronic ulcer of the leg met with especially in girls of delicate constitution, and which has been called Bazin's disease; from the ulcers which result from certain forms of malignant disease, such as rodent cancer, and finally from those met with in chronic glanders. The tertiary ulcers of mucous membranes as seen in the tongue or rectum are, on the whole, less characteristic than those met with in the skin.

Gummatous Infiltration of the Skin ("syphilitic lupus").—This is a lesion, chiefly met with in the face and in the region of the external genitals, in which the skin becomes infiltrated with granulation tissue so that it is thickened, raised above the surface, and acquires a brownish-red colour. It appears as isolated nodules, which may fuse together; the epidermis becomes scaly and is shed, giving rise to superficial ulcers, which are usually covered by crusted discharge. The disease tends to spread, creeping over the skin with a serpiginous, crescentic or horseshoe margin, while the central portion may heal and leave a scar. When untreated the lesion is a very persistent and destructive one. From the fact of its healing in the centre while it spreads at the margin, it may simulate tuberculous disease of the skin. The syphilitic affection can usually be differentiated by observing that the infiltration of the skin is on a larger scale; the progress of the disease is much more rapid, involving in the course of months an area which in the case of tuberculosis would require as many years; the scars formed are sounder and are less liable to break down again; and, finally, the disease rapidly yields to anti-syphilitic treatment.

Tertiary lesions of mucous membranes and of the submucous cellular tissue are chiefly met with in the tongue, nose, throat, larynx, and rectum. They originate as gummata or as gummatous infiltrations which are liable to break down and lead to the formation of ulcers which may prove locally destructive, and, in such situations as the larynx, even dangerous to life. In the case of the tongue the tertiary ulcer may prove the starting-point of cancer; and in the larynx or rectum the healing of the ulcer may be associated with serious cicatricial stenosis or stricture of the passage affected.

Tertiary lesions of the *bones and joints*, of the *muscles*, and of the *internal organs* will be described under these heads. The part played by syphilis in the production of atheroma and of aneurysm will be referred to along with diseases of blood-vessels.

Diagnosis.—From the enormous diversity in the nature and seat of the lesions met with in tertiary syphilis, it is impossible to lay down any general rules for diagnosis, but the reader may be cautioned, on the one hand, against relying upon the absence of a history of antecedent syphilis, and, on the other, of indulging in the habit of diagnosing lesions as syphilitic simply because their origin is obscure.

Treatment.—The most valuable drugs for the treatment of the manifestations of the tertiary period are the iodides of sodium and potassium. While iodides are most effective in promoting the absorption of recent gummata and gummatous infiltrations, they do not remedy the destructive changes brought about by gummata. They are frequently prescribed along with carbonate of ammonium on account of their depressing effects. The dose is usually a matter of experiment in each individual case; five grains three times a day may suffice, or it may be necessary to increase each dose to twenty or twenty-five grains. The symptoms of iodism which may follow from the smaller doses usually disappear on giving a larger amount of the drug. It should be taken after meals, with abundant water or other fluid, especially if given in tablet form. It is advisable to continue the iodides for from one to three months after the lesions for which they are given have cleared up. If the potassium salt is not tolerated, it may be replaced by the ammonium or sodium iodide. A combination of the perchloride of mercury with iodides usually yields more lasting results than the iodides alone. The general health should receive the same careful attention as during the secondary period; much assistance is often obtained from tonics such as arsenic, iron, quinine, and strychnine, from cod-liver oil, and from change of air either by land or sea.

The Local Treatment.—The absorption of a subcutaneous gumma is hastened by the application of a fly-blister. The occasion scarcely ever arises in which it is an advantage to incise a gumma. When a gumma has broken on the surface and left an ulcer, this is treated on general principles, with a preference, however, for applications containing mercury or iodine, or both. If a wet dressing is required to cleanse the ulcer, black wash may be used; if a powder to promote dryness, one containing iodoform; if an ointment is indicated, the choice lies between the red oxide of mercury, or the dilute nitrate of mercury ointment, or one consisting of equal parts of lanolin and vaselin with two per cent. of iodine. Where there is any spreading tendency in ulcers of the skin or mucous membrane, the surface may be cauterised with the acid nitrate of mercury. Deep ulcers, lesions of the bones, larynx, and other parts which prove obstinate, may be treated like the corresponding lesions in tuberculosis—that is, by operative measures directed towards the removal of the diseased tissues.

Second attacks of syphilis, although very rare, do occur, especially in those who have been treated and cured by mercury. So long as the virus of syphilis remains active in the system, it protects the individual against a second attack. As a rule, therefore, there is an interval of several years before a patient who has had syphilis can contract the disease a second time, and when he does so, it is less severe and more amenable to treatment than the first attack.

As connected with this subject, we may refer to the *relapsing false indurated chancre*, described by Hutchinson and by Fournier, as it may be the source of considerable difficulty in diagnosis. A patient who has had an infecting chancre one or more years before, presents a slightly-raised induration on the penis at or close to the site of his original chancre. Often the relapsed induration is so like that of a primary chancre that it is impossible to distinguish it except by the history. If he has lately been exposed to venereal infection it is liable to be regarded as the primary lesion of a second attack of syphilis, but the further progress of the case shows neither bullet-buboes nor secondary manifestations. These facts, together with the disappearance of the induration under iodides, make it very likely that the lesion is really gummatous in character.

INHERITED SYPHILIS.

Inherited syphilis is met with in the offspring of parents suffering from the disease. It presents similar features to the acquired affection, only there is no primary sore, and the first manifestations correspond to those described under acquired secondary syphilis, and result from the general dissemination of the virus through the system.

The more recent the syphilis in either parent the greater is the risk of its being communicated to the offspring; so that a fruitful marriage during the secondary period almost inevitably results in such infection. The capacity of transmitting the disease may be extended, however, to several years after the disappearance of all secondary manifestations, especially in the case of the mother. If a series of children, one after the other, all suffer from inherited taint and show infantile symptoms, it is almost invariably the fact that the mother has herself suffered from syphilis. The longer the interval between the contraction of syphilis and conception, the less severe is the inherited disease. It is impossible to explain such vagaries of syphilitic inheritance as the infection of one twin and the escape of the other.

While it is absolutely certain that either parent may be responsible for the transmission of the disease to the next generation, the exact method of transmission is not known. It is most probable that in the case of a syphilitic mother the infection is conveyed to the fœtus by the placental circulation. In the case of a syphilitic father, it is difficult to believe the common statement that the infection is conveyed to the ovum through the seminal fluid at the moment of conception; it is more probable that the father infects the fœtus through the mother, although she herself may present no external evidence of constitutional syphilis. This is borne out by the fact that years afterwards she may suffer from tertiary lesions.

The syphilitic virus exercises a very injurious influence on the fœtus; it may cause its death during the early months of pregnancy, in which case a miscarriage results; or the fœtus may die nearer the full time, the child being still-born. On the other hand, when the virus is attenuated, the fœtus may survive and be born alive, and after a variable interval the infant presents the manifestations of constitutional syphilis. The taint may be so severe as to cause the death of the infant, or may be so attenuated that it suffers but slightly and grows up more or less like other children, often retaining, however, permanent evidences of its syphilitic inheritance.

Clinical Features.—We are here concerned, not with the severe forms of the disease in which the manifestations appear shortly after birth and soon prove fatal, but with the milder forms in which the infant may present the appearance of perfect health for several weeks.

The usual phenomena are that it ceases to thrive, becomes thin and sallow, suffers from eruptions on the skin and mucous membranes, and from *snuffles*. This term is applied to a condition in which the nasal passages are obstructed by an accumulation of thin muco-purulent discharge mixed with blood, which causes the breathing to be noisy. While this condition may be met with in young infants from a simple catarrh, when it persists and occurs apart from other catarrhal accompaniments it is always suggestive of syphilis. It usually appears within a month after birth and before the eruptions on the skin. When long-continued it is liable to interfere with the development of the nasal bones, so that when the child grows up the bridge of the nose is deficient, the condition being known as the "saddle-nose" deformity (Fig. 28).

Affections of the Skin.—Although all types of syphilitic eruption are met with in the inherited disease, the most important is a *papular* or *papulo-squamous rash*, the papules being of large size, with a smooth shining top and of a reddish-brown colour. It chiefly affects the buttocks and posterior aspect of the thighs, the external genitals, and other parts which are kept moist; but, inasmuch as the same parts are liable to eczema in non-syphilitic infants, attention should be directed in diagnosis to the infiltration of the skin and to the coppery colour of the specific eruption. At the angles of the mouth and at the anus the papules acquire the characters of *condylomata*, which are of great importance in the recognition of syphilis in doubtful cases (Fig. 29). At the angles of the mouth they often ulcerate and leave fine radiating scars (Fig. 28).

Affections of the Mucous Membranes. — In addition to the rhinitis already described as causing snuffles, there may be mucous patches in the mouth, or a general inflammation or stomatitis, which is of special importance because it frequently results in interference with the development of the permanent teeth. Mucous patches or catarrh of the larynx may be associated with a hoarse cry.

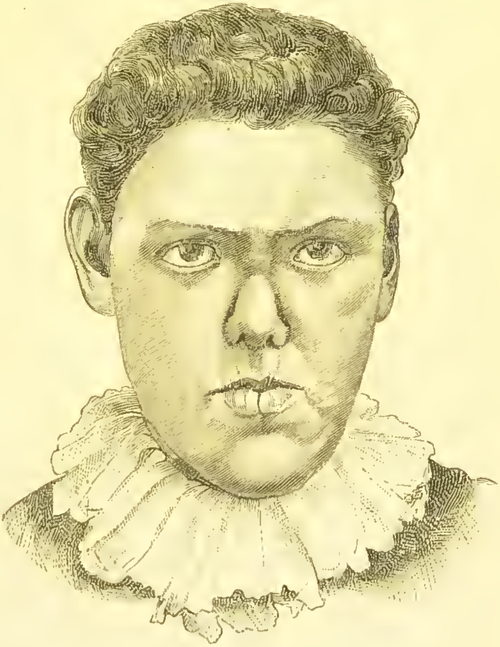

FIG. 28.—Facies of Inherited Syphilis in a girl aged 20.

Affections of the bones are by no means constant. There may be swellings at the ends of the long bones due to inflammation at the epiphysial junctions, most often observed at the upper end of the humerus, or in the bones in the region of the elbow. The infant cries when the part is touched; and as it does not move the limb voluntarily, the condition is often spoken of as *the pseudo-paralysis of syphilis.* The electrical reaction of the muscles, however, is not impaired. Partial displacement and mobility at the ossifying junction may result. Recovery takes place under antisyphilitic treatment and immobilisation of the limb.

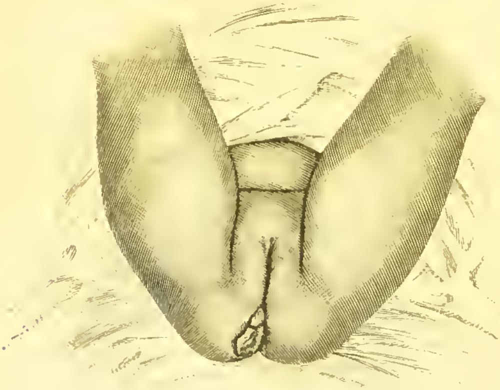

FIG. 29.—Condylomata of Anus in an infant, the subject of Inherited Syphilis.

(From a photograph lent by Mr. Stiles.)

Diffuse thickening of the shafts of the long bones due to a deposit of new bone by the periosteum is sometimes met with.

In the skull, especially of infants who are also suffering from rickets, two characteristic conditions may be met with, respectively known as "bossing" and craniotabes. *The bosses*, or *Parrot's nodes* (Fig. 30), result from the heaping up of new spongy bone beneath the pericranium; and they may be grouped symmetrically around the anterior fontanelle; or may extend along either side of the sagittal suture, which appears as a deep groove—the natiform skull. The bosses disappear in time, but the skull may remain permanently altered in shape, the frontal and parietal eminences often appearing unduly prominent. *Craniotabes* is the term applied when the bone becomes thin and soft, or reverts to its original membranous condition, so that the areas affected dimple under the finger-like parchment or thin cardboard; its localisation in the posterior parts of the skull would indicate that the disappear-

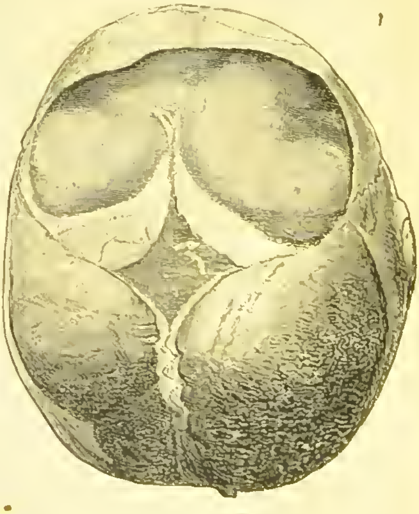

FIG. 30.—Bossing of Skull of Infant in Inherited Syphilis.

ance of the osseous tissue is influenced by the pressure of the head on the pillow. It is entirely recovered from as the child improves in health.

Between the ages of three and six months, certain other phenomena may be observed, such as *effusion into the joints*, especially the knees; *iritis*, in one or in both eyes—a condition which, however, is liable to be overlooked; and enlargement of the spleen and of the liver.

In the majority of cases the child recovers from these early manifestations, especially when efficiently treated with mercury, and may enjoy an indefinite period of good health. On the other hand, when it attains the age of two to four years it may begin to manifest lesions, which, from their being for the most part gummatous in character, are regarded as corresponding to the tertiary period of acquired syphilis. In unfavourable cases the infant fails in health from day to day, its cry is hoarse and feeble, its capacity for sucking diminishes, it becomes emaciated and dies of exhaustion.

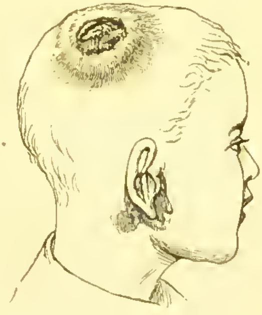

FIG. 31.—Gumma in Skull of boy, the subject of Inherited Syphilis.

(Mr. Scot-Skirving's case.)

The Later or Gummatous Lesions of Inherited Syphilis.—These may occur in relation to the skin and subcutaneous cellular tissue, especially of the legs, as gummata which tend to ulcerate; or in the form of a spreading gummatous infiltration of the skin, which when it ulcerates constitutes what has been called syphilitic lupus, and may leave disfiguring scars, especially when occurring on the face. Ulceration of the palate and throat is sometimes most destructive in character, and in the nose, where it may be associated with putrid discharge from the nostrils,—ozæna,—is liable to produce the most unsightly deformity. The entire palatal portions of the upper jaws, the vomer, turbinate and other bones bounding the nasal and oral cavities may ultimately disappear, so that on looking into the mouth the base of the skull is readily seen. Gummatous disease is also frequently observed in the flat bones of the skull (Fig. 31), in the bones of the hand as syphilitic dactylitis, and in the bones of the forearm and leg. When the tibia is affected the disease is frequently bilateral, and may assume the form of gummatous ulcers and sinuses. In later years the tibia may present alterations in shape resulting from antecedent gummatous disease—for example, nodular thickenings of the shaft, flattening of the crest, or a more uniform increase in thickness and length of the entire shaft of the bone, which, when it is curved in addition, is described as the "sabre-blade" deformity. Among the lesions of the viscera mention should be made of gumma of the testis, which causes the organ to become enlarged, uneven, and indurated. This has even been observed in infants a few months old.

A syphilitic child may occasionally suffer from a succession of these gummatous lesions causing persistent ill-health, and, it may be, waxy disease of the internal organs; or it may recover and present no further manifestations of the inherited taint.

At or near puberty there is frequently observed an affection of the eyes, known as *chronic interstitial keratitis*, the relationship of which to inherited syphilis was first established by Hutchinson. It occurs between the ages of five and eighteen years, and usually affects one eye before the other. It commences as a diffuse haziness or steaminess near the centre of the cornea, and as it spreads, the entire cornea may present the appearance of ground glass. The chief complaint is of dimness of sight which may almost amount to blindness, but there is little pain or photophobia; a certain amount of conjunctival and ciliary congestion is usually present, and there may be *iritis* in addition. The cornea, or parts of it, may become of a deep pink or salmon colour from the formation of new blood-vessels. The affection is very chronic, and may last for from eighteen months to two years. Complete recovery may take place, or slight opacities, especially in the site of former salmon patches, may remain permanently. The disease occasionally relapses. *Choroiditis* and *retinitis* may also occur, as in acquired syphilis. Among the rarer and more serious lesions of the inherited disease may be mentioned gummatous disease in the *larynx and trachea*, attended with ulceration and resulting in stenosis, and lesions of the *nervous system* which may result in convulsions, paralysis, or dementia.

Changes in the Permanent Teeth.—These specially affect the upper central incisors, which are dwarfed and stand somewhat apart in the gum with their free edges converging towards one another. They are tapering or peg-shaped, and present at their cutting margin a deep semilunar notch. These appearances are commonly associated with the name of Hutchinson, who first described them. Affecting as they do the permanent teeth, they are not available for diagnosis until the child is about eight years of age.

In a limited number of cases, about the period of puberty there may develop *deafness*, which is usually bilateral and may become absolute. It is believed to be the result of gummatous changes affecting the nerves of the internal ear.

Diagnosis of Inherited Syphilis.—When there is a typical rash and marked snuffles there is no difficulty in recognising syphilis. Where, however, the rash is scanty or is obscured by coexisting eczema, most reliance should be placed on the distribution of the eruption, on the brown stains which are left after it has passed off, on the presence of condylomata, and of fissuring and scarring at the angles of the mouth. The history of the mother relative to repeated miscarriages and still-born children may afford confirmatory evidence. In doubtful cases the diagnosis may be aided by noting the therapeutic effects of grey powder, which, in syphilitic infants usually effects a marked and rapid improvement in the symptoms and in the general health.

While a considerable number of syphilitic children grow up without showing any trace of their syphilitic inheritance, the majority retain throughout life one or more of the following characteristics, which may therefore be described as *permanent signs of the inherited disease*:—Dwarfing of stature from interference with growth at the epiphysial junctions; the forehead low and vertical, and the parietal and frontal eminences unduly prominent; the bridge of the nose sunken and rounded; radiating scars at the angles of the mouth (Fig. 28); perforation or destruction of the hard palate; Hutchinson's teeth; opacities of the cornea from antecedent keratitis; alterations in the fundus oculi from choroiditis; deafness; depressed scars or nodes on the bones from previous gummata; "sabre-blade" or other deformity of the tibiæ.

The Contagiousness of Inherited Syphilis.—In 1837 Colles of Dublin stated his belief that while a syphilitic infant may convey the disease to a healthy wet nurse, it is incapable of infecting its own mother if nursed by her, even although she may never have shown any symptoms of the disease and the mouth and lips of the infant present unmistakable evidences of syphilis. This doctrine, which is known as *Colles' law*, is generally accepted in spite of the alleged occurrence of occasional exceptions. The older the child the less risk there is of its communicating the disease to others, until eventually the tendency dies out altogether, as it does in the tertiary period of acquired syphilis. It should be added, however, that the contagiousness of inherited syphilis is denied by some observers, who affirm that when syphilitic infants prove contagious the disease has been really acquired at or soon after birth and is not of the inherited type.

There is general agreement that the subjects of inherited syphilis cannot transmit the disease by inheritance to their offspring, and that although they very rarely acquire the disease *de novo*, it is quite possible for them to do so when exposed to infection in the ordinary way.

Prognosis of Inherited Syphilis.—Although responsible for a large, but apparently diminishing, mortality in infancy, the subjects of inherited syphilis may grow up to be as strong and healthy as their neighbours. It is quite the exception to meet with a succession or persistence of the more severe gummatous lesions described as occurring in the skin, in the nose and throat, and in the bones. Hutchinson insists on the fact that there is very little bad health in the general population which can be attributed to inherited syphilis.

Treatment.—The prevention of inherited syphilis has been already considered in relation to the question of the marriage of patients who have acquired the disease. It should be added with regard to the mother that she should take mercury during pregnancy if she has recently suffered from syphilis or if several previous pregnancies have resulted in abortion or in early death of the child (Fournier). The mercury should be given in small doses during the whole time of pregnancy. As regards the infant, it should, if possible, be nursed by its mother, and failing this it should be fed by hand. On the first appearance of syphilitic manifestations it should be brought under the influence of mercury. This is best given as grey powder in half or one grain doses thrice daily : it may be mixed with powdered sugar, or, if digestive derangements arise, may be combined with bismuth or soda. As a rule the grey powder is remarkably well borne by infants, and if they continue to thrive under it, it should be given for from three to six months after all symptoms have disappeared. If the internal administration of mercury does not suit the infant, it may be replaced by a modified inunction. The dilute oleate of mercury is rubbed into the sides of the chest and abdomen, or is applied on the flannel binder twice or thrice weekly. The local lesions are treated on the same lines as in the acquired disease. The general health should be improved in every possible direction ; considerable benefit may be derived from the use of cod-liver oil, and from preparations containing iron and calcium. The gummatous lesions are treated on the same lines as in the acquired disease, but it should be pointed out that in inherited syphilis they are frequently found to be less amenable to the influence of iodides, and that we must depend very largely on measures calculated to improve the general health. Surgical interference may be required in the destructive gummatous lesions of the nose, throat, larynx and bones, either with the object of arresting the spread of the disease, or of removing or alleviating the resulting deformities. In children suffering from keratitis, the eyes should be protected from the light by wearing smoked or coloured glasses, and the pupils should be dilated with atropin from time to time, especially in cases complicated with *iritis*.

Acquired Syphilis in Infants and Young Children.—When syphilis is met with in infants and young children, it is apt to be taken for granted that the disease has been inherited. It is possible, however, for them to acquire the disease—as, for example, while passing through the maternal passages during birth, through being nursed or kissed by infected women, or through the rite of circumcision. The risk of infection which formerly existed by the arm to arm method of vaccination has been abolished by the general adoption of calf lymph.

The clinical features of the acquired disease in infants and young children are very similar to those observed in the adult, with a tendency, however, to be more severe, partly because the disease is often late in being recognised and treated.

CHAPTER XI.

TUMOURS.[1]

Definition—Etiology—General characters of innocent and malignant tumours. Classification of Tumours: I. Connective-tissue tumours: (1) *Innocent: Lipoma, Chondroma, Osteoma, Odontoma, Fibroma, Myxoma*, etc.; (2) *Malignant: Sarcoma*—II. Epithelial tumours: (1) *Innocent: Papilloma, Adenoma, Cystic Adenoma;* (2) *Malignant: Epithelioma, Glandular Cancer, Rodent Cancer, Melanotic Cancer*—III. Dermoids—IV. Teratomata. Cysts: *Retention, Exudation, Implantation, Parasitic, Lymphatic or Serous.* Ganglion.

A tumour or neoplasm is a localised swelling composed of newly-formed tissue which fulfils no physiological function. Tumours tend to grow continuously and quite independently of the growth of the body, and there is no natural termination to their growth. They are to be distinguished from such overgrowths of already-existing parts of the body as are of the nature of hypertrophies or local giantism, and from inflammatory swellings, which usually develop under the influence of a definite cause, which have a natural termination, and which tend to disappear when the cause ceases to act.

The *etiology of tumours* is at present very imperfectly understood. Various factors, acting either singly or in combination, may be concerned in their development. Certain tumours, for example, are the result of some congenital malformation of the particular tissue from which they take origin. This would appear to be the case in many angiomata, chondromata, osteomata, and adenomata. The theory that tumours originate from fœtal residues or "rests" is associated with the name of Cohnheim. These rests are supposed to be undifferentiated embryonic cells which remain embedded amongst fully-formed tissue elements, and lie dormant until they are excited into active growth and give rise to a tumour. This method of origin is illustrated by the development of dermoids from sequestrated portions of the epidermis.

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[1] For the histology of tumours the reader is referred to a text-book of pathology.

Among the local factors concerned in the development of tumours, reference must be made to the influence of irritation and inflammation. These are probably important agents in the causation of many of the tumours met with in the skin and in mucous membranes—for example, cancer of the skin, of the lip, and of the tongue. The part played by a definite injury is doubtful. It not infrequently happens that the development of a tumour is preceded by an injury of the part in which it grows, but it does not necessarily follow that the injury and the tumour are related as cause and effect. It is possible that an injury may stimulate into active growth undifferentiated tissue elements or "rests," and so determine the growth of a tumour, or that it may alter the characters of a tumour which already exists, causing it to grow more rapidly.

The view that the development of tumours is determined by micro-organisms, which has attracted so much attention in recent years, is still under discussion and investigation.

The popular belief that there is some constitutional peculiarity concerned in the causation of tumours is largely based on the fact that certain forms of new growth—for example, cancer—are known to occur with undue frequency in certain families. Some innocent tumours—particularly multiple osteomata and lipomata—are hereditary in the same sense as congenital deformities, such as supernumerary or webbed fingers, and may appear in members of the same family through several generations.

Innocent and Malignant Tumours.

For clinical purposes tumours are arbitrarily divided into two great classes—the innocent and the malignant. The outstanding difference between these two classes is that the evil effects of innocent tumours are merely local and depend for their severity on the environment of the growth, while malignant tumours wherever situated, in addition to producing local effects, injure the general health of the patient and ultimately cause his death.

Innocent, benign, or simple tumours present a close structural resemblance to the normal tissues of the body. They grow slowly, and are usually definitely circumscribed by a fibrous capsule. They are easily enucleated from their capsule, and they do not tend to recur after removal. In their growth they merely push aside and compress adjacent parts, and they present no tendency to ulcerate and bleed unless the overlying skin or mucous membrane is injured from without. They form no attachment to adjacent parts except as a result of accidental inflammation. Although usually solitary, some of them may be multiple from the outset—for example, fatty, fibrous, and bony tumours, warts, and fibroid tumours of the uterus. They produce no constitutional disturbance, wasting, or cachexia. They only threaten life when growing in the vicinity of vital organs, and there merely in virtue of their situation. For example, death may result from an innocent tumour in the air-passages causing suffocation, in the intestine causing obstruction of the bowels, or in the spinal canal causing pressure on the cord.

Malignant tumours usually show a marked departure from the normal structure and arrangement of the tissues of the body. They grow more rapidly than innocent tumours, and they tend to infiltrate their surroundings by sending out prolongations or offshoots into the surrounding tissues. They are therefore very liable to recur after an operation which is restricted to the removal of the main tumour. They are not encapsulated, although they may appear to be circumscribed by condensation of the surrounding tissues. They are rarely multiple at the outset. They show a marked tendency, however, to spread to other parts of the body. Fragments of the parent tumour may become separated and be carried off in the lymph or blood-stream and deposited in other parts of the body, where they give rise to secondary growths. Malignant tumours tend to invade and destroy the overlying skin or mucous membrane, and thus give rise to bleeding ulcers; if the tumour tissue protrudes through the gap in the skin, it is said to fungate. They may give rise to a condition of general ill-health or cachexia, the patient becoming pale, sallow, feverish, and emaciated, probably as a result of chronic poisoning from the absorption of toxic products from the tumour. They ultimately destroy life, it may be by their local effects, such as ulceration and hæmorrhage, by favouring the entrance of septic infection, by interfering with the function of organs which are essential to life, by cachexia, or by a combination of these effects.

It may be added that the situation of a malignant tumour exercises considerable influence on the rapidity, as well as on the mode, in which it causes death. Some cancers, such as that known as "rodent," show malignant features which are entirely local, while others, such as melanotic cancer, exhibit a malignancy characterised by a rapid generalisation of tumour growths throughout the body. Tumours which are structurally alike may show variations in malignancy, not only according to their situation, but also according to the age of the patient and to other factors which are as yet unknown.

In attempting to arrive at a conclusion as to the innocence or malignancy of any tumour, too much reliance must not be placed on its histological features. Its situation, rate of growth, and other clinical features must be taken into consideration. It cannot be too emphatically stated that there is no hard and fast line between innocent and malignant growths. There is an indefinite transition from one to the other, and some tumours occupy an intermediate position between the two. The possibility of the transformation of a benign into a malignant tumour must be admitted. Such a transformation implies a change in the structure of the growth, and has been observed especially in fibrous and cartilaginous tumours, in tumours of the thyroid gland, and in uterine fibroids. The alteration in character may take place under the influence of injury, prolonged or repeated irritation, incomplete removal of the benign tumour, or the altered physiological conditions of the tissues which attend advancing years.

Varieties of Tumours.—In the following description tumours are classified on an anatomical basis, taking in order first the connective-tissue group and subsequently those which take origin in epithelium.

Innocent Connective-tissue Tumours.

Lipoma.—A lipoma is a tumour composed of fat resembling that normally present in the body. The commonest variety is the *subcutaneous lipoma*, which grows from the subcutaneous fat, and forms a soft, irregularly-lobulated tumour (Fig. 32). The fat is arranged in lobules separated by connective-tissue septa which are continuous with the capsule surrounding the tumour, and with the overlying skin, which becomes dimpled or puckered when an attempt is made to pinch it up. As the fat is almost fluid at the body temperature, apparent fluctuation can usually be detected in the swelling. These tumours vary greatly in size, occur at all ages, grow very slowly, and, while generally solitary, are sometimes multiple and occasionally bilaterally symmetrical. They are most commonly met with on the shoulder, buttock, or back. In certain situations, such as the thigh and perineum, they tend to become pedunculated.

A fatty tumour is to be diagnosed from a cold abscess and from a cyst. The distinguishing features of the lipoma are the tacking down and dimpling of the overlying skin, and the lobulation of the tumour which is recognised when it is pressed upon with the flat of the hand.

The treatment consists in dividing the skin and capsule over the tumour and shelling it out. Care must be taken that none of the outlying lobules are detached and left behind. If the overlying skin is closely adherent, it should be removed along with the tumour.

In the neck, axilla, pubic region and elsewhere, a diffuse overgrowth of the subcutaneous fat is sometimes met with, forming large symmetrical tumour-like masses commonly known as a *diffuse lipoma.* As this is not, strictly speaking, a tumour, the term *diffuse lipomatosis* is to be preferred. If causing disfigurement the swelling may be removed, but complete extirpation is usually impossible, as the mass is not encapsulated (Fig. 33).

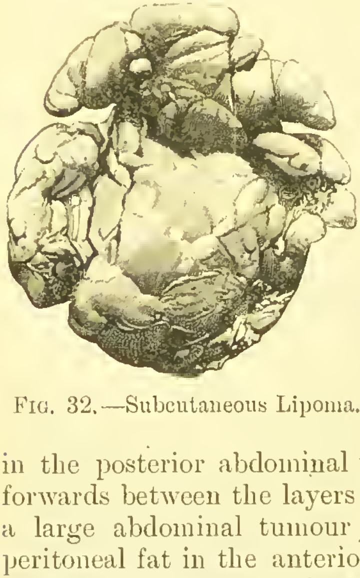

FIG. 32.—Subcutaneous Lipoma.

Lipomata in other Situations.—The *periosteal lipoma* is usually of congenital origin, and is most often met with in the hand; it forms a projecting lobulated tumour which, when situated in the palm, may resemble a compound palmar ganglion. The *subserous lipoma* may arise from the extra-peritoneal fat in the posterior abdominal wall, in which case it tends to grow forwards between the layers of the mesentery and to give rise to a large abdominal tumour; or it may grow from the extra-peritoneal fat in the anterior abdominal wall and protrude from one of the normal openings or through an abnormal opening in the parietes, constituting a *fatty hernia.* *Subsynovial lipomata* grow from the fat surrounding the synovial membrane of a joint, and may project into its interior and give rise to the symptoms of loose body. Lipomata are also met with growing from the adipose connective tissue *between or in the substance of muscles*, and when situated beneath the deep fascia the characteristic signs are obscured and a differential diagnosis may be difficult or impossible.

Chondroma.—A chondroma is a tumour mainly composed of hyaline cartilage. Processes of vascular connective tissue pass in between the nodules of cartilage composing the tumour from the fibrous capsule which surrounds it. On section it is usually of a greyish-blue colour and semi-translucent. The tumour is firm and elastic in consistence, but certain portions may be as hard as bone from calcification or ossification, while other portions may be soft and fluctuating as a result of myxomatous degeneration and liquefaction. These tumours grow slowly and painlessly, and in the course of their growth may surround nerves and arteries without injuring them (Fig. 200). They may cause a deep hollow in the bone from which they originate. All intermediate forms between the innocent chondroma and the malignant chondro-sarcoma are met with. Chondromata may occur in a multiple form, especially in relation to the phalanges and metacarpal bones (Fig. 199). When growing in the interior of a bone a chondroma causes a spindle-shaped enlargement of its shaft, which in the case of a phalanx or metacarpal bone may resemble a tuberculous or syphilitic dactylitis.

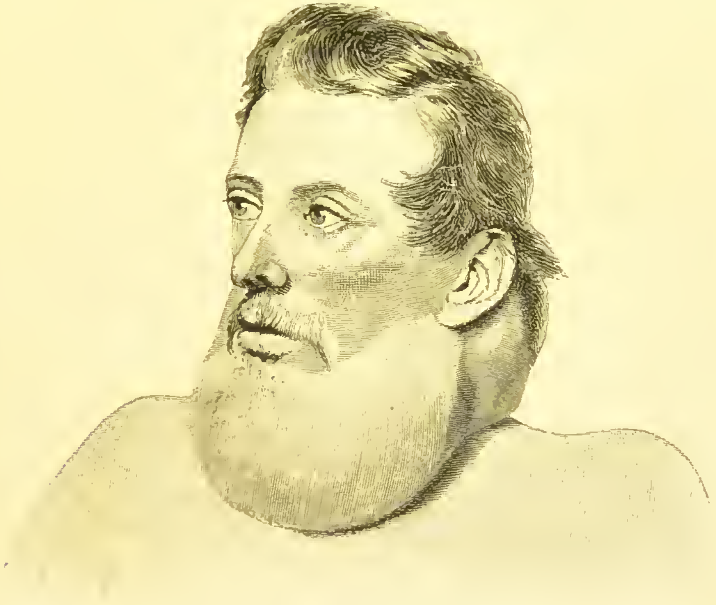

FIG. 33.—Diffuse Lipomatosis of Neck.

Treatment.—In those projecting from the surface of a bone, both the tumour and its capsule should be removed. If in the interior, a sufficient amount of the cortex should be removed to allow of the tumour being scraped out, and care must be taken that no nodules of cartilage are left behind. In multiple chondromata of the hand, when the fingers are crippled and useless, the question of amputation may have to be considered. When a cartilaginous tumour takes on active growth, it must be treated as malignant.

The chondromata which are met with at the ends of the long bones in children and young adults form a group by themselves. They are usually related to the epiphysial cartilage, and it was first suggested by Virchow that they take origin from unaltered islands of cartilage in the interior of the bone which have not been used up in the process of ossification. They are believed to occur more frequently in those who have suffered from rickets in early life. They tend to undergo ossification concurrently with the epiphysial cartilage from which they take origin, and thus constitute what are known as cartilaginous exostoses. These are sometimes met with in a multiple form, and may occur in several generations of the same family.

Tumours in the parotid, submaxillary gland, or testicle are often of the nature of chondro-sarcomata.

Osteoma.—An osteoma is a tumour composed of bony tissue and originating from the skeleton. Two varieties are recognised—the spongy or cancellous and the ivory or compact. The common *spongy* or *cancellous osteoma* is really an ossified chondroma, and is chiefly met with at the ends of the long bones of the limbs. From the fact that it projects from the surface of the bone it is often spoken of as an exostosis. It grows very slowly, and rarely causes any discomfort unless it presses upon a nerve trunk. The Röntgen rays may be of assistance in diagnosis. Operative interference is only indicated when the tumour is giving rise to inconvenience. It is then removed, its base or neck being divided by means of the chisel.

The bony outgrowth from the terminal phalanx of the great toe—known as the *subungual exostosis*—is described elsewhere.

The ivory or *compact osteoma* is composed of dense, compact bone, and usually grows from the bones of the skull. It is usually sessile and solitary, and may grow into the interior of the skull, into the frontal sinus, into the cavity of the orbit or nose, or may fill up the external auditory meatus.

Bony formations sometimes occur in muscles and tendons, especially at their points of attachment to the skeleton, and are described with the diseases of muscles.

Odontoma.—An odontoma is a tumour composed of dental tissues in varying proportions and different degrees of development, arising from teeth-germs or from teeth still in process of growth (Bland Sutton). Odontomata resemble teeth in so far that during their development they remain hidden below the mucous membrane and give little or no evidence of their existence. There then succeeds, usually between the twentieth and twenty-fifth years, an eruptive stage, which is often attended with suppuration, and this may be the means of drawing attention to the tumour. Following Bland Sutton, we may distinguish several varieties of odontoma according to the part of the tooth-germ concerned in their formation.

Epithelial odontomata are derived from persistent portions of the epithelium of the enamel organ, and constitute multilocular cystic tumours which are chiefly met with in the lower jaw. The cystic spaces of the tumour contain a brownish glairy fluid. These tumours have been described by Eve as multilocular cystic epithelial tumours of the jaw.

The *follicular odontoma*, formerly known as a *dentigerous cyst*, is derived from the distension of a tooth follicle. It constitutes a cyst which contains a viscid fluid, and an imperfectly-formed tooth is often found embedded in its wall. The cyst usually forms in relation to one of the permanent molars, and may attain considerable dimensions.

The *fibrous odontoma* is the result of an overgrowth of the fibrous tissue surrounding the tooth sac, which encapsulates the tooth and prevents its eruption. The thickened tooth sac is usually mistaken for a fibrous tumour until after removal the tooth is recognised in its interior.

Composite Odontomata.—This is a convenient term to apply to certain hard dental tumours which are met with in the jaws, and consist of enamel, dentine, and cement. They are to be regarded as being derived from an abnormal growth of all the elements of a tooth germ, or of two or more tooth germs, indiscriminately fused with one another. They may appear in childhood, and form smooth, unyielding tumours, often of considerable size, replacing the corresponding permanent teeth. Many examples of this variety of odontoma, which have been removed from the nasal cavities or from the antrum, have been erroneously regarded as osteomata. They may cause a purulent discharge, and in some cases have been spontaneously extruded after sloughing of the overlying soft parts.

On section, the tumour is usually laminated, and is seen to consist mainly of dentine with a partial covering of enamel and cement.

Diagnosis.—Odontomata are often only diagnosed after operation. When attended with suppuration the condition has been mistaken for disease of the bone. Fibrous odontomata have been mistaken for sarcomata, and portions of the jaw removed unnecessarily. Any circumscribed tumour of the jaw, particularly when met with in a young adult, should suggest an odontoma.

Treatment.—The solid varieties of odontoma can usually be shelled out after dividing the overlying soft parts. In the follicular variety, it is usually sufficient to excise a portion of the wall, scrape out the interior, and remove the tooth if it be present. The cavity is then packed with gauze, and allowed to heal from the bottom.

Fibroma.—A fibroma is a tumour composed of fibrous connective tissue. A distinction may be made between the *soft fibroma*, which is comparatively rich in cells and blood-vessels, and in which the fibres are arranged loosely; and the *hard fibroma*, which is almost entirely composed of closely-packed bundles of fibres often arranged in a concentric fashion around the blood-vessels. The cut surface of the soft fibroma presents a pinkish-white, fleshy appearance resembling the slowly-growing forms of sarcoma; while that of a hard fibroma presents a dry, glistening appearance, aptly compared to watered silk. The soft variety grows much more rapidly than the hard. In certain fibromata—in those, for example, which grow from the periosteum of the base of the skull and project into the naso-pharynx—the blood-vessels are dilated into sinuses and have no proper sheaths. They therefore tend to remain open when divided and to bleed furiously. Transition forms between soft fibromata and sarcomata are met with, so that in operating for their removal it is safer to take away the capsule along with the tumour.

The skin is one of the favourite seats of fibromata,—especially the skin of the buttock,—and they may occur in a multiple form. They are also met with in the subcutaneous and intermuscular cellular tissue; and in the abdominal wall, where they sometimes attain considerable dimensions. The fibrous overgrowths in the skin known as keloid, and molluscum fibrosum, and those met with in the sheaths of nerves, are described elsewhere. Fibroid tumours of the uterus are described with myomata.

Myxoma.—A myxoma is composed of tissue similar to that found in the umbilical cord. The tumour is characterised by its soft, gelatinous, semifluid consistence. The pure myxoma is extremely rare, and occurring, as it does, chiefly in the subcutaneous and intermuscular connective tissue, it resembles clinically the lipoma. Myxomatous tissue is, however, frequently found in other connective-tissue tumours as a result of myxomatous degeneration. This is specially observed in cartilaginous tumours and in sarcomata. Myxomatous tissue is usually a prominent constituent of the "innocent parotid tumour." Mucous polypi of the nose, which are often described as myxomata, are merely pendulous processes of œdematous mucous membrane.

Myeloma.—A myeloma is a tumour composed of tissue resembling the red marrow of bone. It consists of large multinuclear giant cells surrounded by round and spindle cells. The cut surface of the tumour usually presents a deep red or maroon colour. While occasionally met with in tendon sheaths and bursæ, the myeloma occurs most frequently in the cancellous tissue at the ends of the long bones (Fig. 201). Although formerly classified with the sarcomata, it is quite the exception for a myeloma to present malignant features, and it can usually be extirpated by local measures without fear of recurrence. The method of removal varies with its situation and is considered elsewhere.

Myoma.—A myoma is a tumour composed of non-striped muscle fibres. Pure myomata are very rare. They are met with in organs possessed of non-striped muscle, such as the stomach, intestine, urinary bladder, and prostate; in the uterus, which is the most common situation for these tumours, as they contain a considerable admixture of fibrous tissue, they are known as *fibroids* or *fibro-myomata* (Fig. 34). They present on section a fasciculated appearance which may resemble that of a section of balls of cotton. They are encapsulated and vascular tumours, and they frequently attain a large size. They may be single or multiple. While they may occasion neither inconvenience nor suffering, they frequently give rise to profuse hæmorrhage from the uterus, and they may cause serious symptoms by pressing injuriously on the ureters or intestine, or by complicating pregnancy and parturition.

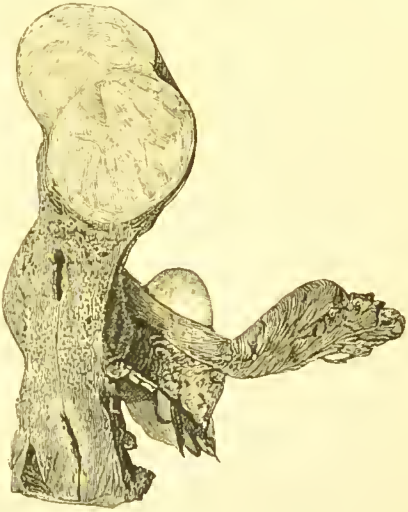

Fig. 34.—Fibro-myoma of Uterus.

(Anatomical Museum of the University of Edinburgh.)

The *Rhabdomyoma* is an extremely rare form of tumour met with in the kidney, uterus, and testicle. It contains striped muscle fibres, and is supposed to originate from a residue of muscular tissue which has become sequestrated during development.

Glioma.—A glioma is a tumour composed of neuroglia. It is met with exclusively in the central nervous system, retina, and optic nerve. It is a slowly-growing, soft, ill-defined tumour which displaces the adjacent nerve centres and nerve tracts, and is liable to become the seat of hæmorrhage and to give rise to pressure symptoms. The glioma of the retina tends to grow into the vitreous humour and to perforate the globe. It is usually of the nature of a glio-sarcoma and is highly malignant.

Angioma, lymphangioma, neuroma, and lymphoma are described with the diseases of the individual tissues.

MALIGNANT CONNECTIVE-TISSUE TUMOURS—SARCOMATA.

The term sarcoma is applied to any connective-tissue tumour which exhibits malignant characters. The essential structural feature is the predominance of the cellular elements over the intercellular substance or stroma, so that a sarcoma resembles the connective tissue of the embryo. The typical sarcoma consists chiefly of immature or embryonic connective tissue. While these tumours may grow from any of the connective tissues of the body they originate most frequently from fascia, intermuscular connective tissue, periosteum, bone-marrow, and skin. They form rounded or nodulated tumours which appear to be encapsulated, but the capsule merely consists of the condensed surrounding tissues which usually contain sarcomatous elements, because of the tendency of the cells of the tumour to infiltrate the adjacent tissues. The consistence of the tumour depends on the nature and amount of the stroma, and on the presence of degenerative changes. The softer medullary forms of sarcoma are composed almost exclusively of cells; while the harder forms—such as the fibro-, chondro- and osteo-sarcoma—are provided with an abundant stroma and are relatively poor in cells. Degenerative changes may produce areas of softening or liquefaction which form cystic cavities in the interior of the tumour. The colour depends on the amount of blood in the tumour and on the results of degeneration. The blood-vessels constitute a prominent feature in sarcomata, and although sometimes possessed of a definite wall, they are usually represented by mere chinks or spaces between the cells of the tumour. This peculiarity accounts for the facility with which hæmorrhage takes place into the substance of the tumour, the persistence of

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the bleeding when the tumour is incised or ulcerates through the skin, and the readiness with which the sarcomatous cells may be carried off into the circulating blood. Sarcomata are devoid of lymphatics, and unless originating in lymphatic structures—for example, in the tonsil—they rarely infect the lymphatic glands. Sarcomata usually infect distant parts through the blood-stream. Minute portions of the tumour grow into the small veins, and becoming detached, are transported by the blood current to distant organs, where they are arrested in the capillaries and give rise to independent secondary growths. These are most frequently situated in the lungs, except when the primary growth lies within the territory of the portal circulation, in which case they occur in the liver. The secondary growths closely resemble the parent tumour. Sarcoma may invade an adjacent vein on such a scale that if the invading portion become detached it may constitute a dangerous embolus. This may be observed in renal sarcoma, the growth taking place along the renal vein until it projects into the inferior vena cava.

In their growth sarcomata compress and destroy neighbouring parts, surround vessels and nerves, and may lead to destruction of the skin, either by invading it or more commonly by causing sloughing from pressure. Once the skin is broken the tumour fungates through the opening. Inflammatory and suppurative changes may take place in sarcomata as a result of pyogenic infection. They vary very much in malignancy, especially as regards rapidity of growth and capacity for dissemination. Certain of them, such as the so-called "recurrent fibroid of Paget," grow comparatively slowly, and are only malignant in the sense that they tend to recur after removal. Others, again, —especially the more cellular tumours,—grow with extreme rapidity, and are early disseminated throughout the body, resembling in these respects the most malignant forms of cancer. Sarcomata occur at all ages. They are usually solitary in the first instance, although it is stated that primary multiple growths are occasionally met with in the skin and in the bones.

Many varieties of sarcomata are recognised according to the structural peculiarities of the growth. Thus, according to the size and character of the cells, we have the small *round-celled* and the large *round-celled* sarcomata, the small and large *spindle-celled* sarcomata, the *giant-celled* and the *mixed-celled* sarcomata. The *lympho-sarcoma* presents a structure similar to that of lymph follicular tissue, and the *alveolar sarcoma* an arrangement of cells in alveoli resembling that seen in cancers. When there is a considerable amount of intercellular fibrous tissue the tumour is called a *fibro-sarcoma.*

The term *endothelioma* or *lymphangio-sarcoma* is applied when the cells of the tumour are derived from the endothelium of lymphatic spaces and vessels. The *angio-sarcomata* are those in which the walls of the blood-vessels play a prominent part in the structure of the tumour. They are sometimes derived from innocent angiomata, and they may be so vascular as to pulsate like an aneurysm and to yield a blowing murmur on auscultation. The *glio-sarcoma*, *myxo-sarcoma*, *chondro-sarcoma*, and *myo-sarcoma* are mixed forms which usually develop in already-existing innocent tumours. The *osteo-sarcoma* is characterised by the formation in the tumour of true bone by a process of ossification, the medullary spaces being occupied by sarcomatous cells in place of marrow. The *osteoid sarcoma* is characterised by the formation of a tissue resembling bone but deficient in lime salts, and the *petrifying sarcoma* by the formation of calcified areas in the stroma. These varieties, although chiefly met with in the skeleton, may occur in the soft tissues such as muscle, and in such organs as the mamma. The pigmented varieties include the *chloroma*, which is of a light green colour, and the *melanotic sarcoma*, which is brown or black. The *psammoma* is a sarcoma attended with the formation of a material resembling sand, and is chiefly met with in the membranes of the brain.

Diagnosis of Sarcoma.—Sarcomata are to be differentiated from inflammatory swellings such as result from tubercle and syphilis, from innocent tumours, and from cancers. The points on which the diagnosis is founded are discussed with the different tissues and organs.

Treatment.—The removal of the tumour by operation is the only satisfactory method of treatment, but in order to be successful it must be undertaken before regional or general dissemination has taken place. It is absolutely essential to remove a considerable area of healthy tissue beyond the apparent margin of the growth. In tumours which approach the surface of the body, the overlying skin should also be removed. If it is impossible to remove the tumour completely, or if there is already evidence of secondary growths, it is better to abstain from operative interference unless there are special indications to be fulfilled—such as the relief of pain or the arrest of hæmorrhage.

In inoperable cases recourse has been had to the injection of the toxins of the streptococcus of erysipelas. This treatment is based on the fact that an intercurrent attack of erysipelas has occasionally resulted in the disappearance of a sarcoma. Coley's fluid, which consists of a sterilised culture of the streptococcus of erysipelas and the bacillus prodigiosus, is the injection usually employed. The two organisms are grown together and the culture is then sterilised by heat. A dose, which varies in amount with the virulence of the culture employed, is injected every second day or so into the subcutaneous tissue at a little distance from the tumour. Each injection is followed by a reaction attended with fever, nausea, and pain; the treatment is in consequence very distressing to the patient. In successful cases, the tumour decreases in size, becomes less painful, and may eventually disappear. This result has been obtained in 16 per cent. of the cases subjected to the treatment, the best results being obtained in spindle-celled tumours (Coley). The effect of the toxins is to cause degeneration of the cellular elements of the growth which then become absorbed. Inflammation and sloughing, when they occur, are septic complications which ought to be avoided. Should no improvement manifest itself after a three weeks' course of the treatment, it should be abandoned. Encouraging results in inoperable cases have also been obtained by the use of the Röntgen rays.

EPITHELIAL TUMOURS.

In the tumours of this class an excessive and erratic growth of epithelium constitutes the essential and distinguishing feature. The innocent forms are the papilloma and the adenoma; while the malignant forms are the carcinomata or cancers.

Papilloma.—Papillomata are tumours which project from a cutaneous or mucous surface, and consist of a central axis of vascular fibrous tissue with a covering of epithelium, which resembles that of the surface from which the tumour grows. In the papillomata of the skin—commonly known as *warts*—the covering consists of epidermis; in those growing from mucous membranes it consists of the surface epithelium. When the surface epithelium projects as filiform processes, the tumour is called a *villous papilloma*, the best-known example of which is met with in the urinary bladder. Papillomatous growths are also met with in the larynx, in the ducts of the breast—the so-called duct papilloma—and in the interior of certain cystic tumours of the breast and of the ovary. Although papillomata are innocent, when subjected to irritation they may become the starting-point of cancer. The clinical features and treatment of the various forms of papillomata are considered under the individual tissues and organs.

Adenoma.—An adenoma is a tumour constructed on the type of, and growing in connection with, a secreting gland. In the substance of such glands as the mamma, parotid, thyroid, and prostate, adenomata are met with as encapsulated tumours. When they originate from the glands of the skin or of a mucous membrane, they tend to project from the surface, and sometimes form pedunculated tumours or polypi.

Adenomata may be single or multiple, and they vary in size from a pea to an adult human head. The tumour is seldom composed entirely of gland tissue. It usually contains a considerable proportion of fibrous tissue, and is called a *fibro-adenoma.* When it contains myxomatous tissue it is called a *myxo-adenoma,* and when the gland spaces of the tumour become distended with accumulated secretion, a *cystic adenoma,* the best examples of which are met with in the mamma and ovary. A characteristic feature of the cystic variety is the tendency the tumour tissue exhibits to project into the interior of the cysts, constituting what are known as intra-cystic growths. They are essentially innocent, and when removed by operation show no tendency to recur. At the same time, transition forms between adenoma and carcinoma are met with, especially in the intestine, and these should be treated on the same lines as cancer.

CARCINOMATA OR CANCERS.

A cancer is a malignant tumour which originates in epithelium. The cells which form the essential constituent of a cancer are derived by proliferation from already-existing epithelium, and they invade the sub-epithelial connective tissue in the form of simple or branching columns. These columns are enclosed in spaces—termed alveoli—which are probably dilated lymphatic spaces, and which communicate freely with the lymphatic vessels. The cells composing the columns and filling the alveoli vary with the character of the epithelium in which the cancer originates. The malignancy of cancer depends on this capacity of the epithelium of invading the tissues in its neighbourhood, and on the capacity of the cells, when transported elsewhere by the lymph or blood-stream, of giving rise to secondary growths.

Cancer may arise on any surface covered by epithelium or in any of the secreting glands of the body, but it is much more common in some situations than in others. It is very frequently met with, for example, in the skin, in certain portions of the alimentary canal, in the breast, the uterus, and the external genitals; less frequently in the gall-bladder, larynx, thyroid, prostate, kidney, and urinary bladder.

A cancer may appear as a papillary growth from a mucous or a skin surface, as an imperfectly-circumscribed nodule in the substance of an organ, or as a diffuse thickening of tubular structures such as the intestine or stomach. The absence of definition in cancerous tumours explains the difficulty in completely removing them by surgical measures, and has led to the practice of complete extirpation of cancerous organs wherever this is possible. The boundaries of the affected organ are, moreover, frequently transgressed, and the epithelial infiltration attacks the surrounding parts. In cancer of the breast, for example, the disease often extends to the adjacent skin, fat, and muscle; in cancer of the lip or tongue, to the lower jaw; in cancer of the uterus or intestine, to the investing peritoneum. In addition to its tendency to infiltrate adjacent tissues and organs, cancer is also liable to give rise to secondary growths. These are most often met with in the nearest lymphatic glands: those in the neck, for example, becoming infected from cancer of the lip, tongue, or throat; those in the axilla, from cancer in the breast; those along the curvatures of the stomach, in cancer of the pylorus; and those in the groin, from cancer of the external genitals. In lymphatic vessels the cancer cells may merely accumulate so as to fill the lumen and give rise to indurated cords, or they may proliferate and give rise to secondary nodules along the course of the vessels. When the lymphatic network in the skin is diffusely infected the appearance is either that of a multitude of secondary nodules, or of a diffuse thickening so that the skin comes to resemble coarse leather. On the wall of the chest this condition is known as cancer *en cuirasse*. Although the cancer cells very constantly attack the walls of the adjacent veins and spread into their interior at an early period, secondary growths due to dissemination by the blood-stream rarely show themselves clinically until late in the course of the disease. It is probable that many of the cancer cells which are carried away in the blood or lymph stream undergo necrosis and fail to give rise to secondary growths. Secondary growths present a faithful reproduction of the structure of the primary tumour. Apart from the lymphatic glands, the chief seats of secondary growths are the liver, lungs, serous membranes, and bone marrow.

The tumour tissue may undergo necrosis, and when the overlying skin or mucous membrane gives way an ulcer is formed. The margins of a *cancerous ulcer* are made up of tumour tissue which has not broken down. They are irregular, usually nodularly thickened or indurated ; sometimes they are raised and crater-like. The floor of the ulcer is smooth and glazed or occupied by necrosed tissue, and the discharge is watery and blood-stained, and as the result of putrefactive changes may become offensive. Hæmorrhage is rarely a prominent feature, but the discharge of blood may constitute a symptom of considerable importance in cancer of internal organs.

Regarding *the causes of cancer*, much attention has been directed in recent years to its possible origin from infection with micro-parasites. Although there are many facts in favour of this theory, nothing conclusive has as yet been proved regarding it. There are a number of conditions which favour the development of cancer, such as inheritance, age, environment, prolonged irritation, and many others. These cannot, however, be regarded as essential causes of cancer ; some other factor would appear to be required, but what that factor is still remains unknown.

The prognosis largely depends on the particular variety of cancer and on its situation. Certain varieties—such as the atrophic cancer of the breast which occurs in old people, and certain forms of cancer in the rectum—are so indolent in their progress that they can scarcely be said to shorten life ; while others—such as the softer varieties of mammary cancer occurring in young women—are among the most malignant of tumours. The mode in which cancer causes death depends to a large extent upon the situation of the tumour. In the gullet or stomach, for example, it usually causes death by starvation ; in the larynx or thyroid, by suffocation ; in the intestine, by obstruction of the bowels ; in the uterus, prostate, and bladder, by hæmorrhage, or by implication of the ureters and kidneys. Independently of their situation, however, those tumours frequently cause death by giving rise to a progressive impairment of health known as the *cancerous cachexia*, a condition which is due to the continued absorption of poisonous products from the tumour. The patient loses appetite, becomes emaciated, pale, and feverish, and gradually loses strength until he dies, apparently from exhaustion.

Treatment.—The only treatment of cancer that affords a prospect of cure is removal by surgical measures. "If carcinomatous disease is to be rooted out, its mode of spread by means of the lymphatic vessels must be borne in mind, and as this occurs at an early stage, and is not evident on examination, a very wide area must be included in the operation. The organ from which the original growth springs should, if practicable, be altogether removed, because its lymphatic vessels generally communicate freely with each other, and secondary deposits have probably already taken place in various parts of it. In addition, the nearest chain of lymphatic glands must also be removed, even though they may not be noticeably enlarged, and in some cases—in cancer of the breast, for example—the intervening lymphatic vessels should be removed at the same time" (Watson-Cheyne).

VARIETIES OF CANCER.

Different varieties of cancer are distinguished according to the character and arrangement of the epithelial cells concerned in their formation.

The *squamous epithelial cancer* or *epithelioma* originates from surfaces covered by squamous epithelium, such as the skin, and the mucous membrane of the mouth and gullet, larynx, bladder, and external genitals. The epithelial columns which constitute the cancer retain the characters of squamous epithelium, and being confined within the lymphatic spaces of the sub-epithelial connective tissue, they become compressed and undergo a horny change. This results in the formation of concentrically laminated masses known as "cell nests" or "epithelial pearls."

The clinical features are usually those of a slowly-growing, indurated tumour which nearly always ulcerates; there is a characteristic induration of the edges and floor of the ulcer, and its surface is often covered with warty or cauliflower-like outgrowths. The infection of the lymphatic glands is remarkably early and constant, and constitutes the most dangerous feature of the disease; the secondary growths in the glands exhibit the characteristic induration, and may themselves break down into ulcers.

Epithelioma frequently originates in long-standing ulcers or sinuses, and in scars, and probably results from the displacement and sequestration of epithelial cells during the process of cicatrisation.

The *columnar epithelial cancer* or *columnar epithelioma* originates in mucous membranes covered with columnar epithelium, and is chiefly met with in the stomach and intestine. It is sometimes described as a *malignant adenoma*, because of its close structural resemblance to the innocent adenoma. Its malignancy is shown by the proliferating epithelium invading the other coats of the stomach or intestine, and by the fact that it gives rise to secondary growths.

Glandular carcinoma originates in glandular organs, such as the breast, and in the glands of mucous membranes and skin. The epithelial cells are not arranged on any definite plan, but are closely packed in irregularly-shaped alveoli. If the alveoli are large and the intervening stroma is scanty and delicate, the tumour is soft and brain-like, and is described as a *medullary* or *encephaloid cancer*. If the alveoli are small and the intervening stroma is abundant and composed of dense fibrous tissue, the tumour is hard, and is known as a *scirrhus cancer*—a form which is most frequently met with in the breast. If the cells undergo degeneration and absorption, and the stroma contracts, the tumour becomes still harder, and tends to shrink or contract and to draw in the surrounding parts, in the breast leading to retraction of the nipple and overlying skin, and in the case of the stomach and intestine to narrowing of the lumen. When the cells of the tumour undergo colloid degeneration, a rare form of cancer—*colloid cancer*—is produced. Melanin pigment is formed in relation to the cells and stroma of certain epithelial tumours, giving rise to the *melanotic cancer* (Figs. 70, 71). *Cystic carcinomata* are those in which cyst-like spaces are formed in the tumour by the accumulation of the secretion of the epithelial cells, or as a result of their degeneration. They are chiefly met with in the breast and ovary, and resemble very closely the cystic adenomata, only they tend to infect their surroundings and to give rise to secondary growths.

Rodent cancer originates in the glands of the skin, and presents a special tendency to break down and ulcerate on the surface. It very rarely infects the adjacent lymphatic glands.

Dermoids.—The term dermoid is applied to any tumour which contains skin or mucous membrane in a situation where these tissues do not occur under normal conditions. They arise, for the most part, in detached or sequestrated portions of skin in situations where, during embryonic life, coalescence takes place between cutaneous surfaces, some of the cells of the epidermis remaining deeply embedded during the process of coalescence and subsequently becoming the starting-point of a dermoid. A dermoid occasionally takes the form of a recess lined with skin, but more commonly it assumes the form of a globular tumour consisting of a central cavity lined by stratified squamous epithelium, supported by a firm membrane of connective tissue —*dermoid cyst.* The cavity is filled with a turbid fluid containing desquamated epithelium, fat droplets, cholesterin crystals, and detached hairs. Delicate hairs may also be found projecting from the epithelial lining of the cyst. Dermoids occur on the trunk in situations where the lateral halves of the body coalesce during development, but they are more commonly met with on the face and neck in the situation of the various clefts and fissures of the embryo.

Faulty coalescence of the cutaneous covering of the back occurs most frequently over the lower sacral vertebræ, giving rise to small congenital recesses, known as post-anal dimples and coccygeal sinuses. These recesses are lined with skin, which is furnished with hairs, sebaceous and sweat glands. If the external orifice becomes occluded, there results a dermoid cyst. Dermoids originating from embryonic canals and passages, which normally disappear before birth, are illustrated by those related to the thyro-glossal duct (lingual dermoids), the post-anal gut (rectal and post-rectal dermoids), and the branchial clefts (branchial dermoids).

Dermoids occurring in the ovary—*ovarian dermoids*—take the form of unilocular or multilocular cysts, the wall of which contains skin, mucous membrane, hair follicles, sebaceous, sweat, and mucous glands, nails, teeth, nipples, and mammary glands, all of these being products of the epiblastic layer of the embryo (Fig. 35). The cavity of the cyst usually contains a pultaceous mixture of shed epithelium, fluid fat and hair. If the cyst ruptures, the epithelial elements are diffused over the peritoneum, and may give rise to secondary dermoids.

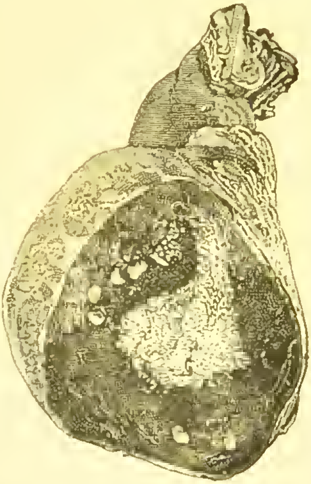

FIG. 35.—Dermoid Cyst of Ovary showing Teeth in its Interior.

Clinical Features.—Although dermoids are of congenital origin, they are rarely evident at birth, and may not give rise to visible tumours until puberty, when the skin and its appendages become more active, or even not till adult life. Superficial dermoids, such as those met with at the outer angle of the orbit, form rounded, definitely-limited tumours, over which the skin is freely movable. They are usually adherent to the deeper parts, and when situated over the skull they may be lodged in a depression or actual gap in the bone. Sometimes the cyst becomes infected and suppurates, and finally ruptures on the surface. This may lead to a natural cure, or a persistent sinus may remain. The ovarian dermoid appears clinically as an abdominal or pelvic tumour, and may give rise to urgent symptoms if it becomes strangulated from torsion of its pedicle.

The treatment consists in removing the cyst. When it is impossible to remove the whole of the lining membrane by dissection, the portion which is left should be destroyed with the cautery. The treatment of the ovarian dermoid consists in removing the tumour by laparotomy.

Teratoma.—A teratoma is distinguished from a dermoid by its containing tissues or structures derived from all of the germinal layers of the embryo. Teratomata result from partial dichotomy or cleavage of the trunk axis of the embryo, and are found exclusively in connection with the skull and vertebral column. They include such monstrosities as conjoined twins or parasitic fœtus. They are more commonly met with as irregularly-shaped tumours, usually growing from the posterior surface of the sacrum. On dissection, these are found to contain a curious mixture of tissues—bones, skin, and portions of viscera, such as the intestine or liver. The question of the removal of such tumours requires to be considered in relation to the conditions present in each individual case.

CYSTS.[1]

Cysts are usually rounded sacs, the wall being composed of fibrous tissue lined by epithelium or endothelium; while the contents are fluid or semi-solid, and vary in character according to the organ or tissue in which the cyst has originated.

Retention and Exudation Cysts.—*Retention cysts* develop where the duct of a secreting gland is partially obstructed; the secretion tends to accumulate, and the gland and its duct become distended into a cyst. They are frequently met with in secreting organs, such as the mamma, pancreas, salivary glands, mucous and sebaceous glands. Sebaceous cysts or wens are described with diseases of the skin, and other retention cysts with the surgery of their respective regions. *Exudation cysts* arise from the distension of cavities which are not provided with excretory ducts, such as those in the thyroid.

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[1] Cysts which form in relation to new growths have been considered with tumours.

Implantation cysts are caused by the accidental implantation of portions of the epidermis into the underlying connective tissue, as may occur in accidental wounds by needles, awls, forks, or thorns. The implanted epidermis proliferates and forms a small cyst. They are chiefly met with on the palmar aspect of the fingers, and vary in size from a split pea to a cherry. The treatment consists in removing them by dissection.

Parasitic cysts are produced by the growth within the tissues of cyst-forming parasites, the best known being the tænia echinococcus, which gives rise to the hydatid cyst.

Blood cysts may result from an extravasation of blood into the tissues, from hæmorrhage taking place into a pre-formed cyst, or from the saccular pouching of a varicose vein.

Lymphatic or serous cysts are met with as the result of the distension of lymphatic spaces or vessels, and in the lymphangiomata which include the cystic hygroma or hydrocele of the neck.

Ganglion.

This term is applied to a cyst filled with a clear jelly or colloid material, and usually met with in the immediate vicinity of a joint.

The carpal ganglion—popularly known as a sprained sinew—is met with as a smooth, rounded, or oval swelling on the dorsal aspect of the carpus, usually towards its radial side. It is situated over one of the intercarpal or other joints in this region, and may appear to be connected with one or other of the extensor tendons. The skin and fascia are movable over the cyst. The cyst varies in size from a pea to a pigeon's egg, and it becomes tense and more prominent when the hand is flexed towards the palm. Its appearance is usually ascribed to some strain of the wrist—for example, in girls learning gymnastics, or in women after a heavy washing. It may cause no symptoms beyond the deformity, or it may interefere with the use of the hand, especially in grasping movements, and when the hand is dorsiflexed. In females it may give rise to pain which shoots up the arm.

The tarsal ganglion is situated on the dorsum of the foot over one or other of the intertarsal joints. It is usually smaller, flatter, and more tense than that met with over the wrist, so that it is sometimes mistaken for a bony tumour. It rarely causes any symptoms, unless so situated as to be pressed upon by the boot.

Ganglia in the region of the knee are usually situated over the interval between the femur and tibia, most often on the outer aspect of the joint in front of the tendon of the biceps. The swelling, which may attain the size of half a walnut, is tense and hard when the knee is extended, and becomes softer and more prominent when it is flexed. They are chiefly met with in young adult males who follow laborious occupations or who indulge in athletics. They may cause stiffness, discomfort, and impairment in the use of the limb.

Ganglionic cysts are met with in other situations than those described, but they are so rare as not to require separate mention.

Ganglia are to be diagnosed by their situation and physical characters; bursæ, synovial cysts, and new growths are the swellings most likely to be mistaken for them. The diagnosis is sometimes only cleared up by evacuating their clear, jelly-like contents.

Pathological Anatomy.—On dissection the wall of the cyst is found to consist of dense fibrous tissue closely adherent to or fused with the surrounding tissues. A ganglion cannot be shelled out like a sebaceous cyst. There is no endothelial lining, and the fibrous tissue of the wall is in immediate contact with the colloid material in the interior. The microscopical appearances give the impression that the colloid material is derived by a process of degeneration from the surrounding fibrous connective tissue. In the region of the knee the ganglion is usually multilocular, and consists of a meshwork of fibrous tissue, the meshes of which are occupied by colloid material.

It is often stated that a ganglion originates from a hernial protrusion of the synovial membrane of a joint or tendon sheath into the surrounding tissues. We have not been able to demonstrate any communication between the cavity of the cyst and that of an adjacent tendon sheath or joint. It is possible, however, that the cyst may originate from a minute portion of synovial membrane being protruded and strangulated so that it becomes disconnected from that to which it originally belonged; it may then degenerate and give rise to colloid material, which accumulates and forms a cyst. Ledderhose and others regard ganglia as entirely new formations in the peri-articular tissues, resulting from colloid degeneration of ordinary connective tissue, at first in numerous small areas which later fuse to form a ganglion. Ganglia are probably, therefore, of the nature of degeneration cysts.

Treatment.—If a ganglion is causing deformity or disability, it is most easily got rid of by an aseptic modification of the old-fashioned seton. The overlying skin and cyst wall are transfixed by a stout curved needle carrying a double thread of thick silk-worm gut, the ends of which are cut short, and a dressing applied. A week later the threads are removed and the minute punctures sealed with collodion. The action of the threads is to excite an aseptic granulation of the cyst wall, which results in its obliteration. Where this fails, recourse should be had to excision. Puncture with a tenotomy knife, and scraping the interior, and the injection of irritants, are alternative, but less satisfactory, methods of treatment.

The so-called "compound palmar ganglion" has been shown to be a tuberculous disease of the tendon sheaths, and will be described with the diseases of tendon sheaths

CHAPTER XII.

INJURIES.

CONTUSIONS—WOUNDS: *Varieties*—WOUNDS BY FIREARMS AND EXPLOSIVES: *Varieties*—BURNS AND SCALDS—INJURIES PRODUCED BY ELECTRICITY.

CONTUSIONS.

A CONTUSION or bruise is a laceration of the subcutaneous soft tissues, without solution of continuity of the skin. When at the same time the integument gives way, a *contused wound* results. Bruising occurs when force is applied to a part by means of a blunt object, whether in the form of a direct blow, a crush, or a grazing form of violence. Violence acting at right angles to the part tends to produce localised lesions extending deeply, while forces acting obliquely to the surface give rise to lesions which are more diffuse, but comparatively superficial. It is well to remember that those suffering from scurvy or hæmophilia (bleeders), and fat and anæmic females, are liable to bruising or ecchymosis from comparatively trivial injuries.

Clinical Features.—Three degrees of contusion are recognised, in all of which discoloration and swelling are the predominant features.

Contusions of the first degree (*contusion with ecchymosis*) are characterised by the occurrence of numerous minute and discrete punctate hæmorrhages scattered through the superficial layers of the skin, which is slightly œdematous. The effused blood is rapidly reabsorbed.

Contusions of the second degree (*contusion with extravasation*) are those most commonly met with. The extravasated blood may be widely diffused through the cellular tissue of the part, especially where this is loose and lax, as in the region of the orbit, the scrotum and perineum, and on the chest-wall. A blue or bluish-black discoloration occurs in patches varying in size and depth with the degree of force which produced the injury, and in shape with the instrument employed. It is most intense in regions where the skin is naturally thin and pigmented. In parts where the extravasated blood is only separated from the oxygen of the air by a thin layer of epidermis or by a mucous membrane, it retains its bright arterial colour. These points are often well illustrated in cases of black eye, where the blood effused under the conjunctiva is bright red, while that in the eyelids is almost black. In severe contusions associated with great tension of the skin, blebs often form on the surface and constitute a possible source of septic infection. When deeply situated, the blood tends to spread along the lines of least resistance, partly under the influence of gravity, passing under fasciæ, between muscles, along vascular sheaths or connective-tissue spaces, so that it may only reach the surface after some time, and at a considerable distance from the seat of injury. This fact is sometimes of importance in diagnosis, as, for example, in certain fractures of the base of the skull, where discoloration appears a few days after the accident under the conjunctiva or behind the mastoid process.

Blood extravasated deep in the tissues gives rise to a firm, resistant, doughy swelling, in which there may be elicited, on deep palpation, a peculiar sensation, not unlike the crepitus of fracture.

The majority of contusions tend to spontaneous cure, during the progress of which characteristic alterations in the colour of the effused blood take place as a result of changes in the blood pigment. In from twenty-four to forty-eight hours the margins of the blue area become of a violet hue, and as time goes on the discoloured area increases in size, and becomes successively green, yellow, and lemon-coloured at its margins, the central part being the last to change its hue. The rate at which this play of colours proceeds is so variable, and depends on so many circumstances, that no time limits can be laid down. During the disintegration of the effused blood the adjacent lymphatic glands may become enlarged, and on dissection may be found to be pigmented.

Sometimes the blood collects in a space—for example, under the aponeurosis of the occipito-frontalis, in the tunica vaginalis, or in a large connective-tissue space, and constitutes a *hæmatoma*. The encapsulation of such an effusion, by proliferation of the connective tissue around it, may give rise to a *hæmorrhagic cyst*.

It occasionally happens that, from the tearing of lymphatic vessels, *serous fluid* is extravasated; and in a few rare cases circumscribed collections of *oily fluid* have been met with.

In all contusions of the second degree there is marked swelling of the area involved, as well as pain and tenderness. The temperature may rise to 101° F., or even higher, a form of aseptic fever (Fig. 8). The degree of shock is variable, but sudden syncope frequently results from severe bruises of the testicle, abdomen, or head, and occasionally marked nervous depression follows these injuries.

Contusions of muscles or nerves may produce partial atrophy and paresis. This is often seen in injuries in the region of the shoulder.

In alcoholic or other debilitated patients suppuration is liable to ensue in bruised parts, infection doubtless taking place from cocci circulating in the blood.

Contusions of the third degree (*contusion with complete disintegration of tissue*) are usually associated with severe fractures, dislocations, laceration of large vessels, nerves, or muscles, to which injuries they are of secondary importance.

Treatment.—If the patient be seen immediately after the accident, elevation of the part, and firm pressure applied by means of a thick pad of cotton wool and an elastic bandage, are useful in preventing effusion of blood. Ice-bags and evaporating lotions are to be used with caution, as they are liable to lower the vitality of the damaged tissues and lead to gangrene.

When extravasation has taken place before the patient is seen, massage is the most speedy and efficacious means of dispersing the effused blood. The part should be rubbed centripetally several times a day, for from fifteen to thirty minutes, unless the presence of blebs or abrasions of the skin prevent this being done. When this is the case the use of antiseptic dressings is called for to prevent infection and to promote healing, after which massage is employed.

When the tension caused by the extravasated blood threatens the vitality of the skin, incisions may be made, but only if absolute asepsis can be assured. The blood from a hæmatoma may be withdrawn by a trocar and cannula, and the puncture sealed with collodion. Septic complications must be met on general surgical principles.

Wounds.

A wound is a solution in the continuity of the skin or mucous membrane and the underlying tissues.

Wounds are described as incised, punctured, and contused and lacerated.

Incised Wounds.—The best examples of incised wounds are those made deliberately by the surgeon in the course of an operation. Wounds accidentally inflicted by cutting instruments and suicidal cut-throat wounds are also of the incised variety. It should be borne in mind in connection with medico-legal inquiries, that wounds of soft parts which closely overlie a bone, such as the skull, the tibia, or the patella, although inflicted by a blunt instrument, may have all the appearances of incised wounds.

Clinical Features.—One of the most characteristic features of an incised wound is its tendency to gape. This is evident in long skin wounds, and especially when the cut runs across the part, or when it extends deep enough to divide muscular fibres at right angles to their long axis. The gaping of a wound, further, is more marked when the underlying tissues are in a state of tension—as, for example, in inflamed parts. Incised wounds in the palm of the hand, the sole of the foot, or the scalp, however, have little tendency to gape, because of the close attachment of the skin to the underlying fascia.

Incised wounds, especially in inflamed tissues, tend to bleed profusely, and when a vessel is only partially divided and is therefore unable to contract, it continues to bleed longer than when completely cut across.

The *special risks* of incised wounds are: (1) division of large blood-vessels, leading to profuse hæmorrhage; (2) division of nerve trunks, resulting in motor and sensory disturbances; and (3) division of tendons or muscles, interfering with motion. Septic infection is, of course, a risk common to all varieties of wounds.

Treatment.—The first indication in the treatment of incised wounds is the arrest of hæmorrhage. This may be effected by pressure, torsion, or ligature, and must be as complete as possible, as the accumulation of blood in the wound interferes with union. The wound should be purified, if necessary, by washing with sterilised saline solution or with an antiseptic lotion, and the edges approximated by sutures. The raw surfaces must be brought into accurate apposition, care being taken that no inversion of the cutaneous surface takes place. In extensive and deep wounds it may be advisable to unite the deeper structures by a separate series of *buried* sutures of catgut or other absorbable material. For the approximation of the skin edges, stitches of horse-hair, fishing-gut, or fine silk are the most appropriate. These stitches of coaptation may be interrupted (Fig. 38) or continuous (Figs. 36, 37). In small superficial wounds on exposed parts, stitch marks may be avoided by approximating the edges with strips of gauze fixed in position by collodion, or by subcutaneous sutures of fine catgut.

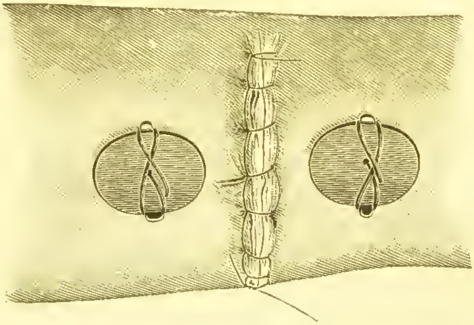

FIG. 36.—Continuous Suture, uniting Edges of Wound. Button Sutures of Relaxation.

When there is any difficulty in bringing the edges of the wound into apposition, a few interrupted "relaxation stitches" may be introduced wide of the margins to take the strain off the coaptation stitches (Fig. 38). Stout silk, fishing-gut, or silver wire may be employed for this purpose. When the tension is extreme, Lister's button suture (Fig. 36) may be employed. Relaxation stitches should be removed in four or five days, and stitches of coaptation in from ten to fourteen days. Stitches on the face and neck should be removed earlier to prevent or diminish the unsightliness of the scar.

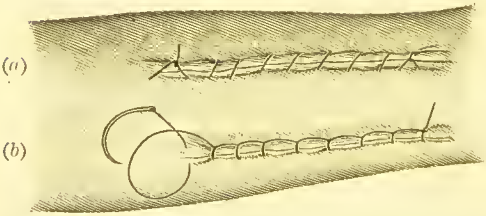

FIG. 37.—Continuous Sutures: (a) Glover's Stitch; (b) Blanket or Button-hole Stitch.

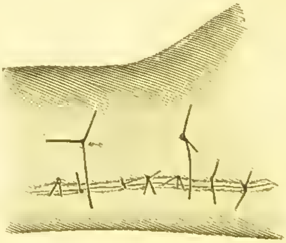

FIG. 38.—Interrupted Sutures. Two wide Sutures of Relaxation.

Drainage.—In wounds in which no cavity has been left, and in which there is no reason to suspect septic infection, drainage is unnecessary. When the deeper parts of an extensive wound cannot be brought into accurate apposition, and especially when there is any prospect of oozing of blood or serum into the space left—as in amputation stumps or in such wounds as are left after excision of the breast—drainage is indicated. It is a wise precaution also to insert drainage-tubes into wounds in very fat patients where there is the slightest reason to suspect the presence of septic organisms. Rubber or glass tubes are the best drains, but where it is desirable to leave little mark a few strands of horse-hair or of sterilised worsted, or a small roll of oiled-silk protective forms a satisfactory substitute. Gauze is not a satisfactory draining material. Except when sepsis occurs all drains may be removed in from one to four days.

The wound should be protected by means of suitable dressings, and the part kept at rest by bandages, splints, or other appropriate means.

Punctured Wounds.—Punctured wounds are produced by narrow, pointed instruments, and the sharper and smoother the instruments the more do the resulting injuries resemble incised wounds; while from more rounded and rougher instruments the edges of the wound are always more or less contused or lacerated. The depth of punctured wounds greatly exceeds their width, and the damage to subcutaneous parts is usually greater than that to the skin. When the instrument transfixes a part, the edges of the wound of entrance may be inverted, and those of the exit wound everted. If the instrument be a rough one, these conditions may be reversed by its sudden withdrawal.

Punctured wounds neither gape nor bleed much. Even when a large vessel is implicated, the bleeding usually takes place into the tissues rather than externally.

The risks incident to this class of wounds are: (1) The extreme difficulty of rendering them aseptic on account of the uncertainty as to their depth, and the way in which the surface wound closes on the withdrawal of the instrument. This risk is greater when a dense fascia has been perforated, as it immediately closes and renders purification or the removal of foreign bodies difficult. (2) Different forms of aneurysm may result from the puncture of large vessels. (3) Perforation of a joint, or of a serous cavity, such as the abdomen, thorax, or skull, materially adds to the danger.

Treatment.—The first indication is to sterilise carefully the whole extent of the wound, and to remove any foreign body which may have been left in it. That this may be done satisfactorily it is usually necessary to enlarge the wound, freely dividing injured fasciæ. Blood-clots are cleared out, bruised tissues pared away, and the whole wound surface purified with pure carbolic or peroxide of hydrogen. Any blood-vessel which is punctured should be cut across and tied, and divided muscles, tendons, or nerves must be sutured. After hæmorrhage has been arrested the wound is drained. If septic complications ensue they are met by incisions and drainage.

Contused and Lacerated Wounds.—These may be considered together, as they so occur in practice. They are produced by crushing, biting, or tearing forms of violence—such as result from machinery accidents, firearms, or the bites of animals. In addition to the irregular wound of the integument there is always more or less bruising of the parts beneath and around, and the lesions are usually much wider in area than at first sight appears.

Wounds of this variety usually gape considerably, especially when there is much laceration of the skin. It is not uncommon to have considerable portions of skin, muscle, or tendon completely torn away.

Hæmorrhage is seldom a prominent feature, as the crushing or tearing of the vessel walls leads to the obliteration of their lumen.

The special risks of these wounds are: (1) Sloughing of the bruised tissues, especially when attempts to sterilise the wound have not been completely successful. (2) Reactionary hæmorrhage from displacement of clots when the circulation improves as the shock passes off. (3) Secondary hæmorrhage as a result of septic processes ensuing in the wound. (4) Loss of muscle or tendon, interfering with motion. (5) Cicatricial contraction. (6) Gangrene, which may follow occlusion of main vessels, or virulent infective processes. (7) It is not uncommon to have particles of carbon embedded in the tissues after lacerated wounds, leaving unsightly, pigmented scars. This is often seen in coal-miners, and in those injured by firearms, and is to be prevented by carefully removing all gross dirt from the edges of the wound.

Treatment.—In severe wounds of this class implicating the extremities, the most important question that arises is whether or not the limb can be saved. In examining the limb, attention should first be directed to the state of the main blood-vessels, in order to determine if the vascular supply of the part beyond the lesion is sufficient to maintain its vitality. Amputation is usually called for if there is complete absence of pulsation in the distal arteries and if the parts are blue and cold. If at the same time important nerve trunks are lacerated, the probability of gangrene ensuing is increased. If, in addition, there is extensive destruction of large muscular masses or of important tendons, or comminution of the bones, amputation is usually imperative. Stripping of large areas of skin is not in itself a reason for removing a limb, as much can be done to replace skin by grafting, but when it is associated with other lesions it favours the major operation. In considering these points it must be borne in mind that the damage to the deeper tissues is always more extensive than appears at first sight, and that in many cases it is only possible to estimate the real extent of the injury by administering an anæsthetic and exploring the wound. In doubtful cases the possibility of rendering the parts aseptic will often decide the question for or against amputation. If this be accomplished, the success which attends conservative measures is often remarkable. It is permissible to run an amount of risk to save an upper extremity which would be quite unjustifiable in the case of a lower limb. The age and occupation of the patient must also be taken into account.

When it is decided to make the attempt to save the limb the wound must be carefully and thoroughly purified. If necessary it may be enlarged, so that all bruised tissue in which gross dirt has become engrained may be clipped away with scissors. The raw surface should be thoroughly cleansed with sterilised salt solution or peroxide of hydrogen. All rough scrubbing with strong antiseptics is to be avoided, as being only calculated to depress the vitality of the tissues without increasing the probability of rendering the wound aseptic. The wound should be left unstitched, freely drained or packed with gauze, and immobilised by suitable splints. When granulations have formed, skin-grafting may hasten the healing of the wound.

Wounds by Firearms and Explosives.

The present consideration of gunshot wounds refers chiefly to such injuries as are met with in civil practice. The subject will be dealt with under the following heads:—Pistol-shot wounds, wounds by sporting-guns, wounds by rifle-bullets, and shell wounds.

Whatever the nature of the weapon, the wound is of the *contused and lacerated* variety. Its severity depends on the size, shape, and nature of the missile, its velocity, the range at which the weapon is discharged, and the part of the body struck.

Shock is a prominent feature in most cases of gunshot wound, but its degree, as well as the time of its onset, varies with the extent and seat of the injury, and with the mental state of the patient when shot. At the moment of injury the patient experiences a sensation which is variously described as being like the lash of a whip, a blow with a stick, or an electric shock.

There is not much pain at first, but later it may become severe, and is usually associated with intense thirst, especially when much blood has been lost.

Recent experience has shown that even in active warfare the great majority of gunshot wounds heal by first intention if treated on antiseptic principles from the first, by the intelligent application of the field dressing with which each soldier is provided. Nussbaum puts it tersely—"The fate of the wounded rests in the hands of the one who applies the first dressing."

Considerable difference of opinion exists as to the advisability of removing embedded bullets, some authorities holding that unless causing definite symptoms they should be left alone, while others advocate their extraction to obviate possible later complications and to relieve the mind of the patient. It is needless to say that, in localising bullets as a preliminary to operation, invaluable aid is obtained by the use of the Röntgen rays. This procedure has, to a large extent, superseded the employment of special probes and other instruments for this purpose. Nélaton's probe, which is furnished with a knob of unglazed porcelain at its end, was formerly much used in searching for bullets, the lead of the bullet leaving a mark on the porcelain. It is, however, of no special value in detecting the presence of modern bullets, as the hard mantle leaves no mark on the china. Various forms of electric bullet detectors or "telephone probes" are employed. The probe is made of some insulating material, and carries in its interior two wires connected with a battery. When the ends of these wires come in contact with a metallic substance, such as a bullet, and the circuit is thus completed, the needle of a galvanometer is moved or a small bell is rung.

Pistol-shot Wounds.—Wounds inflicted by pistols, revolvers, and small air-guns are of frequent occurrence in civil practice, the weapon being discharged usually by accident, but frequently with suicidal, and sometimes with homicidal intent.

With all calibres and at all ranges except on actual contact, the wound of entrance is smaller than the bullet. If the weapon is discharged within a foot of the body, the skin surrounding the wound is usually stained with smoke and burned, and the hair singed. At ranges varying from six inches to thirty feet, grains of powder may be found embedded in the skin or lying loose on the surface, the greater the range the wider being the area of spread. When black powder is used the embedded grains usually leave a permanent bluish-black tattooing of the skin. When the weapon is placed in contact with the skin the subcutaneous tissues are lacerated over an area of two or three inches around the opening made by the bullet, and smoke and powder staining and scorching are more marked than at longer ranges.

When the bullet perforates, the exit wound is usually larger and more extensively lacerated than the wound of entrance. Its margins are as a rule everted, and it shows no marks of flame, smoke, or powder.

Pistol-wounds only produce dangerous effects when fired at close range, and when the cavities of the skull, the thorax, or the abdomen are implicated. These injuries will be described with regional surgery.

Pistol-shot wounds of *joints* and *soft parts* are seldom of serious import apart from the risk of septic infection.

Treatment.—The treatment of recent wounds of the soft parts consists in purifying the bullet tracks with a view to preventing septic complications. An attempt may have to be made to remove the bullet, the exact position of which should, if possible, be determined by the use of the Röntgen rays. When the patient is not seen until the wound has healed, and if the bullet is deeply lodged and causes no inconvenience, it may be left alone. Probes should be avoided in searching for bullets in soft parts overlying joints or serous cavities; the wounds should be enlarged, if necessary, to admit the finger for purposes of exploration.

Wounds by Sporting-guns.—The weapons most commonly used in this country for sporting purposes are the 12- or 16-bore gun, and, less frequently, the smaller 20-bore. The cartridges are usually loaded with amberite or other smokeless powder, and carry a charge of from two to three hundred small pellets (No. 5 or No. 6 shot), weighing from 300 to 450 grains.

The charge of small shot leaves the muzzle of the gun as a cylinder, gradually becoming spherical as the pellets scatter, till, at about twenty feet from the muzzle, the dispersion is complete, each pellet taking its own course.

When the object struck is within one and a half to two feet of the muzzle of the gun, the charge makes a single, sharply-cut wound, somewhat oval in outline, having much the appearance of a wound produced by a single bullet. The wound of exit is much larger and more ragged, and the tissues through which the shot has passed are torn and lacerated by the scattering of the pellets. If a bone is struck it is shattered and the soft parts around it are destroyed by the deflection of the shot, which tear up the tissues through which they pass. Portions of bone may be driven out through the exit wound and cause great laceration of its edges.

Pellets striking the shafts of long bones may become flattened or distorted, and when cancellated bone is struck they remain embedded in it.

When the charge impinges over one of the large cavities of the body the shot may scatter widely through the contained viscera, and there is often no exit wound. In the thorax, for example, if a rib be struck, the charge, and possibly fragments of bone, will penetrate the pleura, and be dispersed throughout the lung; in the head, the skull may be shattered and the brain torn up; and in the abdomen, the hollow viscera may be perforated in many places and the solid organs lacerated.

On covered parts the clothing, by deflecting the shot, influences the size and shape of the wound. The entrance wound is increased in size and more ragged, and portions of the clothes may be driven into it.

By the discharge of small shot, at a distance of from two to four feet from the muzzle the central wound is slightly ragged; and beyond four feet the pellets begin to disperse so that separate punctures occur round the central opening. As the distance increases these outlying punctures make a wider and wider pattern, till at ten feet they cover an area of about five inches. The central opening is at its largest about six or seven feet from the muzzle; beyond this it gradually gets smaller, till at ten or fifteen feet it is scarcely recognisable, and at twenty feet it has completely disappeared, each individual pellet making its own puncture.

When the shot have diverged so as to strike singly they seldom do much harm. When a large number of pellets lodge close to one another the skin is very apt to slough. Fatal damage has been done to the brain and to the aorta by a single pellet. The eye also may be seriously injured by a single shot.

Small shot fired at longer ranges—up to about a hundred and fifty feet—usually go through the skin, but seldom pierce the fascia, and lie embedded in the subcutaneous tissue, from which they can readily be extracted.

The wad of the cartridge behaves very erratically: so long as it remains flat it goes off with the rest of the charge, and is often buried in the wound; but if it curls up or turns on its side it is usually deflected and flies clear of the shot. It may make a separate wound.

A charge of small shot is much more destructive to blood-vessels, tendons, and ligaments than a single bullet, which in many cases pushes such structures aside without actually dividing them. In the abdomen and chest also the damage done by a full charge of shot is much more extensive than that inflicted by a single ball, the deflection of the pellets leading to a greater number of perforations of the intestines and more widespread laceration of solid viscera.

When a charge of small shot fired at close range strikes the surface of the body obliquely, considerable portions of soft tissues may be carried away, leaving a large ragged wound, the margins of which are much torn, and in which stray pellets are often embedded.

Wounds with Rifle-bullets.—The vast majority of wounds inflicted by rifle-bullets are met with in the field during active warfare, and fall to be treated by military surgeons. They occasionally occur accidentally, however, during range practice, and may then come under the notice of the civil surgeon.

It is only necessary here to consider the effects of modern small-bore bullets—that is, anything less than 0·350 inch in diameter, as no others are now used by civilised armies.

The Lee-Metford rifle, which is the present arm of the British army, fires a bullet (Mark II.) 1·25 inch in length, 0·303 inch in diameter, and weighing 215 grains. It is composed of a core of lead hardened with antimony, incased in an envelope of cupro-nickel alloy, and it leaves the muzzle of the gun with a velocity of 2000 feet per second.

The Mauser bullet is 1·21 inch long, 0·275 inch in diameter, and weighs about 175 grains. It has a steel sheath, and its muzzle velocity is 2380 feet per second.

These may be taken as the types of modern military projectiles. The trajectory is practically flat up to 500 yards. In destructive effect there is not much difference between them. They will kill up to a distance of two miles. The hard covering is employed to enable the bullet to take the grooves in the rifle, and to prevent it stripping as it passes through the barrel. It also increases the penetrating power of the missile, but diminishes its "stopping" power, unless a vital part or a long bone be struck. By removing the covering from the point of the bullet, as is done in the Dum-Dum bullet, or by splitting the end, the bullet is made to expand or "mushroom," when it strikes the body, and its stopping power is thereby greatly increased, the resulting wound being very much more severe. These "soft-nosed" expanding bullets are to be distinguished from "explosive" bullets, which contain substances which detonate on impact. High-velocity conical bullets are less likely to lodge in the body than the old spherical balls. Spent shot may merely cause bruising of the surface, or they may pass through the skin and lodge in the subcutaneous tissue.

A blank cartridge fired at close range may cause a severe wound, and, if black powder is used, leave a permanent bluish-black pigmentation of the skin.

Effects of Small-bore Bullets on different Tissues.—When the projectile passes through the *soft parts without striking a bone*, it makes a small round aperture at the point of entrance, and an exit wound which is very slightly if at all larger—indeed, they can scarcely be distinguished from one another. So minute are these wounds that they may readily be overlooked, especially as they rarely bleed externally. The wounds are smaller than the bullet which produces them, and their size does not appear to bear any constant relation to the range at which they are fired. As a rule no clothing or other foreign body is carried into the wound, and healing by first intention is almost invariable. Shock is comparatively slight, even when the abdomen is perforated, and the patient often feels as if he had been sharply struck with a hammer. In short-range wounds there is usually considerable hæmorrhage into the subcutaneous tissues.

When the *shaft of a long bone* is struck the bullet may be much distorted, and as it ploughs its way through the soft parts may inflict severe damage on them. If fired at short range a high-velocity bullet may pierce the bone, or may carry away a segment and project it through the exit wound, which is then much larger than the wound of entrance. In such cases the shaft of the bone is widely fissured and comminuted. Shrapnel bullets, being spherical, cause more comminution but less fissuring than conical bullets.

In wounds implicating *joints and the cancellous ends of long bones*, the bullet drills its way right through the spongy bone doing little damage, and although there may be considerable effusion into the joint the lesion in the bone seldom implicates the articular surfaces. Fragments may be broken off, but the function of the joint is rarely interfered with except as a result of excessive callus formation.

Wounds of large *blood-vessels* are comparatively common, and fatal hæmorrhage may occur. If it be possible to ligature the divided ends of the vessel the limb can usually be saved, as the collateral circulation is rapidly re-established. Primary traumatic aneurysm or arterio-venous aneurysm may result from wounding of the vessels by a bullet; or if the vessel walls be contused these conditions may supervene later.

Nerves may be temporarily paralysed by a bullet passing near but without actually touching them. Sometimes a bullet perforates a nerve trunk, making a button-hole through its substance and causing partial loss of function. Even without operation the ultimate results in these conditions are often satisfactory. In other cases the nerve is completely divided, and there may be considerable difficulty in approximating the severed ends. When a nerve is implicated in a cicatrix much benefit results from freeing it by operation, or from resecting the affected portion of the nerve.

Head Injuries.—The impact of a bullet on the skull may be followed by more profound degrees of cerebral concussion than any other form of trauma, and death frequently results from paralysis of the respiratory and cardiac centres.

In nearly all cases the skull is fractured, and the inner table is invariably damaged over a wider area than the outer. This is true even of grazing wounds which produce a long gutter-shaped fracture of the outer table with wide splintering of the inner. Fragments of bone are usually found perforating the dura mater and damaging the cerebral cortex.

The experience of the recent South African campaign showed that operative interference is indicated in nearly all wounds of the skull; that the trephine should be applied over the wound of entrance; and that the results on the whole are eminently satisfactory.

Penetrating wounds of the *thorax* are sometimes attended with a considerable degree of hæmothorax, which may necessitate aspiration of the pleural cavity on account of embarrassment of respiration. In other cases there is very little hæmorrhage, the only external sign of which is a slight and transient hæmoptysis.

Operative treatment is seldom indicated except for the removal of splinters of rib, or of a bullet which is causing symptoms and which has been localised by the X-rays.

Wounds of the *heart* are usually rapidly fatal, but recovery has taken place in cases in which there was every reason to believe that the heart had been perforated.

Wounds of the Abdomen.—Recent experience has demonstrated that small-bore bullets usually produce comparatively slight disturbance even when they perforate hollow as well as solid viscera; and that for such injuries the results of surgical interference are extremely disappointing. In the South African War about 60 per cent of perforating abdominal wounds recovered without operation—a result which is attributed to the fact that modern bullets make very minute punctures in the intestine, which immediately close. As the peristalsis is arrested by the shock of the injury, nothing escapes, especially if, as is usually the case in active warfare, the patient has been fasting for some hours before being wounded. The punctures in the gut have therefore time to become occluded by peritoneal adhesions before the intestinal contents pass along the injured segment.

The passage of a small-bore bullet through a *solid viscus*—such as the liver, spleen, pancreas, or kidney—produces comparatively little laceration; hence there is little or no bleeding, and few symptoms of any moment ensue.

Operations performed on the field are contra-indicated in abdominal injuries, as they are calculated to prevent the formation of the adhesions which naturally close the perforations, or to break down such as have occurred.

Shell Wounds and Wounds produced by Explosions.—It is convenient to consider together the effects of the bursting of shells fired from heavy ordnance in warfare, and those resulting in the course of blasting operations from the discharge of dynamite or other explosives, or from the bursting of steam boilers or pipes, the breaking of machinery, and similar accidents occurring in civil industries.

Two types of shell are used by artillery: the *common shell*, which consists of a hollow metal cylinder containing a bursting charge of powder, discharged either by a time fuse or by impact;

and *Shrapnel shell*, the cavity of which contains several hundred large round bullets, which are dispersed by the bursting of the shell, which is timed to take place from 50 to 100 yards in front of the enemy. The destructive effect is produced by the fragments into which the shell bursts, together with, in the case of Shrapnel, the shower of bullets thus set free.

Wounds inflicted by shell-fragments and Shrapnel bullets tend to be extensive in area, but they do not penetrate deeply, and they show great contusion, laceration, and destruction of the tissues implicated. On account of their comparatively low velocity the missiles frequently lodge in the tissues. Shell wounds are attended with a considerable degree of shock. On account of the wide area of contusion which surrounds the actual wound produced by shell-fragments, amputation, when called for, should be performed some distance above the torn tissues, and the prognosis in all cases should be guarded, as there is considerable risk of sloughing of the flaps. Unlike the wounds produced by small-bore bullets, those resulting from shell-fragments comparatively seldom run an aseptic course.

Wounds produced by dynamite explosions, the bursting of boilers, and the breaking of machinery have the same general characters as shell wounds. Fragments of stone, coal, or metal may lodge in the tissues, and if infected cause septic complications.

All such injuries are to be treated on the general principles governing contused and lacerated wounds.

BURNS AND SCALDS.

A burn results from the application of dry heat to the tissues of the body; and a scald from the application of moist heat. This distinction, however, has no clinical importance.

Burns are most frequently produced by flames—as, for example, when a child's clothes catch fire; by gas, paraffin, or gunpowder explosions; or by contact with molten metal or hot solids. Electricity and exposure to Röntgen rays also produce similar lesions. Scalding is usually due to contact with boiling fluids, or to the escape of steam in boiler explosions. In young and debilitated subjects hot poultices may produce injuries of this kind.

It is an interesting fact that in old people with enfeebled circulation mere exposure before a strong fire may produce severe degrees of burning, the clothes covering the part being uninjured. This usually occurs about the feet, legs, or knees the patient usually having fallen asleep before the fire while intoxicated (Fig. 39).

The damage done to the tissues by strong caustics, such as fuming nitric acid, sulphuric acid, caustic potash, nitrate of silver, or arsenical paste, presents pathological and clinical features almost identical with those resulting from heat.

Pathology of Burns.—Much discussion has taken place regarding the explanation of the rapidly-fatal issue in extensive superficial burns. On post-mortem examination the lesions found in these cases are: (1) general hyperæmia of all the organs of the abdominal, thoracic, and cerebro-spinal cavities; (2) marked leucocytosis, with destruction of red corpuscles, setting free hæmoglobin which lodges in the epithelial cells of the tubules of the kidneys; (3) minute thrombi and extravasations throughout the tissues of the body; (4) degeneration of the ganglion cells of the solar plexus; (5) general œdema and degeneration of all the lymphoid tissue throughout the body; (6) cloudy swelling of the liver and kidneys, and softening and enlargement of the spleen. Bardeen suggests that these morbid phenomena correspond so closely to those met with where the presence of a toxin is known to produce them, that in all probability death is similarly due to the action of some poison, the source and nature of which are as yet unknown.

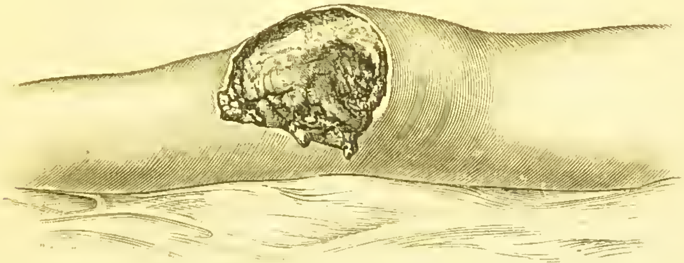

FIG. 39.—Burn of Fifth Degree, exposing the Patella. The patient, an old man, while intoxicated fell asleep before the fire, with his knees crossed. The trousers were not burned.

(Mr. J. M. Cotterill's Case.)

Clinical Features.—Local Phenomena.—The most generally-accepted classification of burns is that of Dupuytren, which is based upon the depth of the lesion. Six degrees are thus recognised: (1) hyperæmia or erythema; (2) vesication; (3) partial destruction of the thickness of the true skin; (4) total destruction of the thickness of the true skin; (5) charring of muscles; (6) charring of bones.

It must be observed, however, that burns met with at the bedside always illustrate more than one of these degrees. The deeper forms are always associated with those less deep, and the clinical picture is made up of the combined characters of all. A burn is classified in terms of its most severe portion. It is also to be remarked that the extent and severity of a burn usually prove to be greater than at first sight appears.

Burns of the first degree are associated with erythema of the skin, due to hyperæmia of its blood-vessels, and result from scorching by flame, from contact with solids or fluids below 212° F., or from exposure to the sun's rays. They are characterised clinically by acute pain, redness, transitory swelling from oozing of serum into the tissues, and subsequent desquamation.

Burns of the Second Degree—Vesication of the Skin.—These are characterised by the occurrence of vesicles or blisters which are scattered over the hyperæmic area, and contain a clear yellowish or brownish fluid. On removing the raised epidermis the congested and highly-sensitive papillæ of the skin are exposed. Unna has found that pyogenic bacteria are invariably present in these blisters. Burns of the second degree leave no permanent scar but a persistent discoloration often results. In rare instances the burned area may become the seat of keloid.

Burns of Third Degree—Partial Destruction of the True Skin.—The epidermis and papillæ are destroyed in patches, leaving hard, dry, and insensitive sloughs of a yellow or black colour. The pain in these burns is intense, but passes off during the first or second day, to return again, however, when, about the end of a week, the sloughs separate and expose the nerve filaments of the underlying skin. Granulations spring up to fill the gap, and are rapidly covered by epithelium, derived partly from the margins and partly from the remains of skin glands which have not been completely destroyed. These latter appear on the surface of the granulations as small bluish islets which gradually increase in size, become of a greyish-white colour, and ultimately blend with one another and with the edges. The resulting cicatrix may be slightly depressed, but otherwise exhibits little tendency to contraction and deformity.

Burns of Fourth Degree—Total Destruction of the True Skin.—These follow the prolonged application of any form of intense heat. Large, black, dry eschars are formed, surrounded by a zone of intense congestion (Fig. 40). As the cutaneous nerves are completely destroyed pain is not severe. Septic infection is very liable to result and to lead to wide destruction of the surrounding skin. The amount of granulation tissue necessary to fill the gap is therefore great; and as the epithelial covering can only be derived from the margins—the skin glands being completely destroyed—the healing process is slow. The resulting scars are irregular, deep and puckered, and show a great tendency to contract. Keloid frequently develops in such cicatrices (Fig. 41). When situated in the region of the face, neck, or flexures of joints, much deformity and impairment of function may result (Figs. 42, 43).

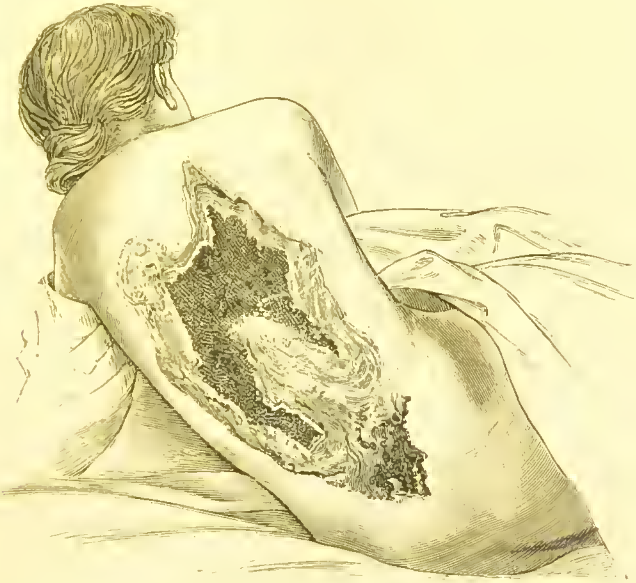

FIG. 40.—Burn of Fourth Degree, with large black Slough in centre, in course of treatment by Picric Acid. The patient recovered.

In *burns of the fifth degree* the lesion extends through the subcutaneous tissue and involves the muscles; while in those of the *sixth degree* it passes still deeper and implicates the bones. These burns are comparatively limited in area as they are usually produced by prolonged contact with hot metal or caustics. Burns of the fifth and sixth degrees are sometimes met with in epileptics who fall into the fire during a fit. Large blood-vessels, nerves, trunks, joints, or serous cavities may be implicated.

General Phenomena.—It is customary to divide the clinical history of a severe burn into three periods; but it is to be observed that the features characteristic of the periods have been greatly modified since burns have been treated on the same lines as other infected wounds.

The *first period* lasts for from thirty-six to forty-eight hours, during which time the patient remains in a more or less profound state of shock, and there is a remarkable absence of pain. When shock is absent or little marked, however, the amount of suffering may be very great. When the injury proves fatal during this period, death is due to shock, probably aggravated by the poisonous substances which are believed to enter the circulation. In fatal cases there is often evidence of cerebral congestion and œdema.

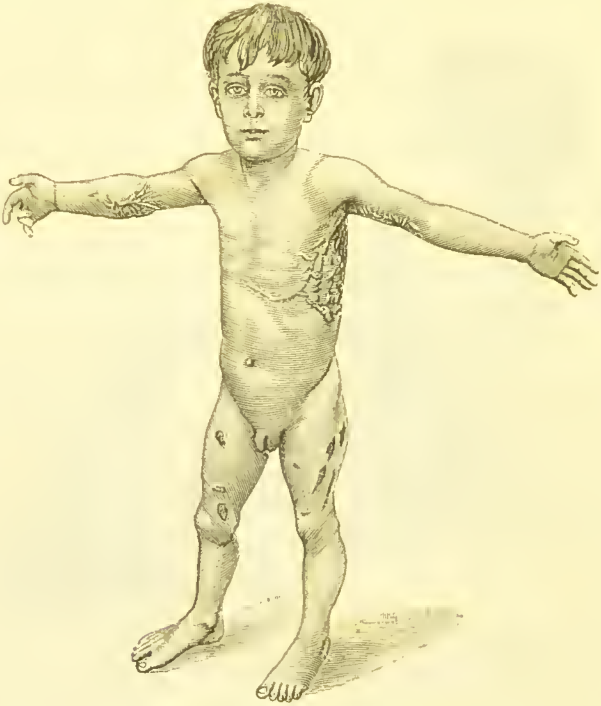

FIG. 41.—Keloid in Cicatrices resulting from Burn of Third Degree. The area under the left axilla was skin-grafted by Thiersch's method, and the keloid developed only in the spaces between the grafts.

The *second period* begins when the shock passes off, and lasts till the sloughs separate. The outstanding features of this period are fever, the temperature rising to 102°, 103°, or 104° F.; and congestive or inflammatory conditions of internal organs, giving rise to such clinical complications as bronchitis, broncho-pneumonia, or pleurisy—especially in burns of the thorax; or meningitis and cerebritis, when the neck or head is the seat of the burn. Intestinal catarrh associated with diarrhœa is not uncommon; and ulceration of the duodenum leading to perforation has been met with in a few rare cases. These phenomena are much more prominent when septic infection takes place and the discharge is profuse. It seems more than probable that they are all to be attributed more or less directly to septic absorption, especially in view of the fact that they have become less frequent and less severe since burns have been treated on rigidly antiseptic principles. Albuminuria is a fairly constant symptom in severe burns, and is probably due to congestion of the kidneys. In burns implicating the face, neck, mouth, or pharynx, œdema glottidis is a dangerous complication. During this period the pain subsides.

The *third period* begins when the sloughs separate, usually between the seventh and fourteenth days, and lasts till the wound heals, its duration depending upon the size, depth, and asepticity of the raw area. The chief causes of death during the third period are septic absorption in any of its forms; waxy disease of the liver, kidneys, or intestine; less commonly erysipelas, tetanus, or other diseases due to infection by specific organisms. It is stated that duodenal ulcers have sometimes perforated and caused death during the third period.

The *prognosis* in burns depends on (1) the superficial extent, and, to a much less degree, the depth of the injury. When more than one-third of the entire surface of the body is involved, even in a mild degree, death usually follows. (2) The situation of the burn is important. Burns over the serous cavities—abdomen, thorax, or skull—are, other things being equal, much more dangerous than burns of the limbs. The risk of œdema glottidis in burns about the neck and mouth has been already referred to. (3) Children are more liable to succumb to shock during the early periods, but withstand prolonged suppuration better than adults. (4) When the patient survives the shock the presence or absence of sepsis is the all-important factor in prognosis.

Treatment.—The *general treatment* consists in combating the shock by warmth; by alcoholic stimulants given by the mouth or rectum; or by hypodermic injections of ether, brandy, or strychnine. When the pain is severe morphin must be injected.

Local Treatment.—This must be carried out on the most rigid antiseptic lines, a general anæsthetic being administered, if necessary, to ensure the purification being carried out thoroughly. After carefully removing the clothes, the whole of the burned area is gently, but thoroughly, washed with a mild antiseptic lotion, such as warm boracic or weak lysol, followed by sterilised saline solution. As pyogenic bacteria are invariably found in the blisters of burns, these must be opened and the raised epithelium removed.

The dressings subsequently applied should meet the following indications: the relief of pain; the prevention of sepsis; and the promotion of cicatrisation.

The application which most satisfactorily fulfils these requirements is *picric acid*, which is applied to the surface as a watery solution—made up of picric acid, 1½ drams; absolute alcohol, 3 ounces; distilled water, 40 ounces.

Pads of lint or gauze are lightly wrung out of the solution and applied over the whole of the reddened area. These are covered with antiseptic wool, *without* any waterproof covering, and retained in position by a many-tailed bandage. The injured part should be kept at rest by a splint or other suitable appliance. The dressing should be changed once or twice a week, any portion of the original dressing which remains perfectly dry being left undisturbed. The value of a general anæsthetic in dressing extensive burns, especially in children, can scarcely be overestimated.

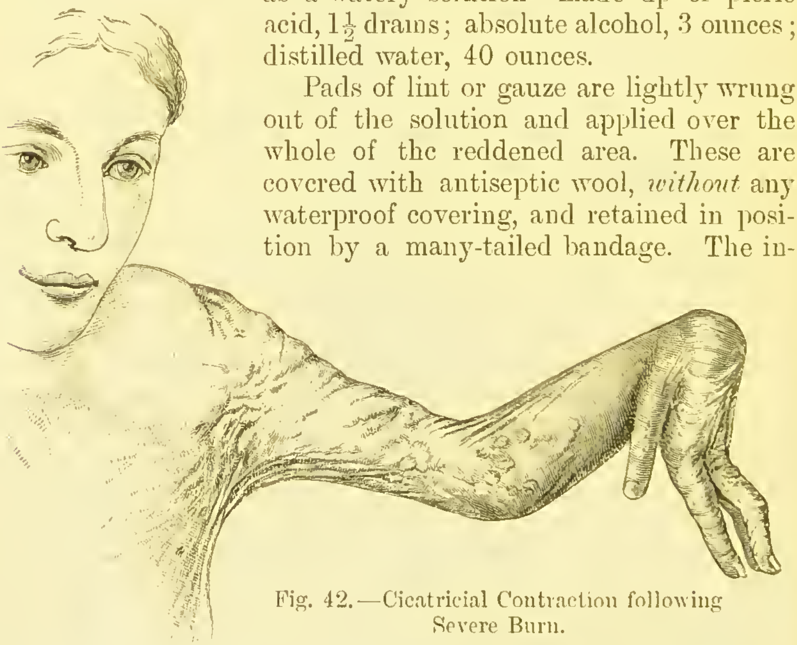

Fig. 42.—Cicatricial Contraction following Severe Burn.

Picric acid yields its best results in the more superficial burns, but is useful as a primary dressing in all. As soon as the sloughs separate and a granulating surface forms, the ordinary treatment for a healing sore is instituted (p. 79). A slough under which pus has collected should be cut away with scissors to permit of free drainage.

An alternative method of treating extensive burns is by immersing the part, or even the whole body when the trunk is affected, in a bath of boracic lotion kept at the body temperature, the lotion being frequently renewed.

When a burn is already septic when first seen by the surgeon it is to be treated on the same principles as govern the treatment of other infected wounds.

All moist or greasy applications, such as Carron oil, carbolic oil and ointments, and all substances like collodion and dry powders, which retain discharges, entirely fail to meet the indications for the rational treatment of burns, and should be abandoned.

Thiersch grafting is of great value in hastening the healing after extensive burns, and in preventing cicatricial contraction. The *deformities* which are so liable to develop from contraction of the cicatrices resulting from burns are treated on the general principles governing plastic operations. In the region of the face (Fig. 43), neck, and flexures of joints (Fig. 42), where they are most marked, the contracted bands may be divided and the parts stretched, the raw surface left being covered by Thiersch grafts or by flaps of skin raised from adjacent surfaces and glided or twisted into position.

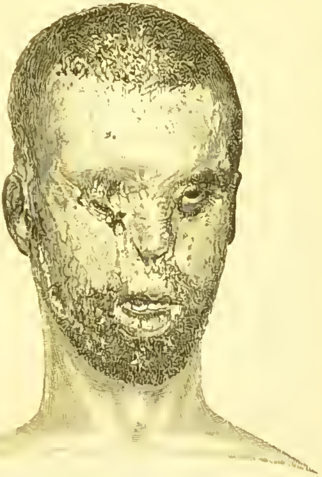

Fig. 43.—Cicatricial Contraction after Burn, causing Deformity of Eyelids, Nose, and Mouth.

INJURIES PRODUCED BY ELECTRICITY.

Lesions of the nature of burns frequently result from the action of electricity on the tissues of the body. They differ sufficiently from ordinary burns to merit separate description, and may be considered under the headings of (1) injuries produced by exposure to the Röntgen rays, (2) electrical burns, and (3) lightning-stroke.

Injuries produced by Exposure to the Röntgen Rays.—There is still some difference of opinion amongst authorities as to whether these lesions are due to the influence of electricity or to the action of the X-rays themselves. It would appear that they only follow exposure to electric discharges emanating from a Crooke's tube; that the patient experiences no sensation of electric shock or of heat; and that prolonged or repeated exposure is usually necessary to their production.

Two distinct varieties of burn are recognised—an erythematous form, resembling a superficial burn; and an ulcerative and sloughing form, corresponding to a burn of the third or fourth degree.

The *erythematous* form is usually met with on the back of the hands and fingers of those who work with the Röntgen apparatus, but occasionally occurs in patients who have been subjected to the rays for diagnostic or therapeutic purposes. The first symptom is the appearance of a red patch on the skin, attended with itching, but devoid of pain. This seldom appears sooner than two or three weeks after the exposure. The skin becomes dry, tends to crack, and finally desquamates. The hairs are lost and the nails become brittle. The sense of touch is sometimes impaired. The condition is very persistent, and usually lasts for several months. It disappears spontaneously, but is very liable to recur if the parts be again exposed to the influence of the rays. Sometimes the hair is without any other lesion; it may begin to grow again in a few weeks, or the loss may be permanent.

The *ulcerative* form is met with in patients subjected to the rays for a prolonged period, and usually begins within a week of the exposure, although in some cases the first signs have been delayed for two or three weeks. The onset is marked by redness of the skin and slight pain. In a few days a blister containing sero-purulent fluid rises, and after bursting leaves a raw surface which is extremely painful. A slough slowly forms and gradually increases in size, spreading through the deep fascia and exposing the muscle. The prominent features of this form are the extreme slowness with which the sloughs separate,—sometimes a process of several months' duration,—and the severity of the pain, which usually calls for the administration of opiates. The raw surface left after the separation of the slough is very slow to heal, and during the process fresh patches of necrosis may appear.

The treatment consists in purifying the part with a mild antiseptic, such as boracic lotion, and the use of non-irritating protective dressings. When granulations have appeared the application of Thiersch grafts greatly expedites healing.

Electrical burns usually occur in those who are engaged in industrial undertakings where powerful electrical currents are employed.

The lesions—which vary from a slight superficial scorching to complete charring of parts—are most evident at the points of entrance and exit of the current, the intervening tissues apparently escaping injury.

The more superficial degrees of electrical burns differ from those produced by heat in being almost painless and in healing very slowly, although as a rule they remain dry and aseptic.

The more severe forms are attended with a considerable degree of shock, which is not only more profound, but also lasts much longer than the shock in an ordinary burn of corresponding severity. The parts at the point of entrance of the current are charred to a greater or less depth. The eschar is at first dry and crisp, and is surrounded by a zone of pallor. For the first thirty-six to forty-eight hours there is comparatively little pain, but at the end of that time the parts become exceedingly painful. In a majority of cases, in spite of careful purification, a slow form of moist gangrene sets in, and the slough spreads both in area and in depth, until the muscles and often the large blood-vessels and nerves are exposed. A line of demarcation eventually forms, but the sloughs are exceedingly slow to separate, taking from three to five times as long as in an ordinary burn, and during the process of separation there is considerable risk of secondary hæmorrhage taking place from erosion of large vessels.

Treatment.—Electrical burns are treated on the same lines as ordinary burns, by thorough purification and the application of dry antiseptic dressings, with a view to avoiding the onset of moist gangrene. Experience has shown that when amputation is necessary, unless the limb is removed well above the level of the dead tissue, it is not advisable to stitch the flaps, as the divided muscles usually necrose up to their points of origin, and are very slowly thrown off as sloughs. After this has occurred and granulations have formed, skin-grafting is of great value in hastening healing.

Lightning-stroke.—In a large proportion of cases lightning-stroke proves instantly fatal. In non-fatal cases the patient suffers from a profound degree of shock, and there may or may not be any external evidence of injury. In the mildest cases red spots or wheals—closely resembling those of urticaria—may appear on the body, but they usually fade again in the course of twenty-four hours. Sometimes large patches of skin are scorched or stained, the discoloured area showing a markedly arborescent appearance. In other cases the injured skin becomes dry and glazed, resembling parchment. Appearances are occasionally met with corresponding to those of a superficial burn produced by heat. The chief difference from ordinary burns is the extreme slowness with which healing takes place. Localised paralysis of groups of muscles, or even of a whole limb, may follow any degree of lightning-stroke. Treatment is mainly directed towards combating the shock, the surface lesions being treated on the same lines as ordinary burns.

CHAPTER XIII.

CONSTITUTIONAL EFFECTS OF INJURIES.

SYNCOPE — SHOCK — COLLAPSE — DELIRIUM IN SURGICAL PATIENTS: *Delirium in general; Delirium Tremens; Traumatic Delirium* — FAT EMBOLISM.

SYNCOPE, SHOCK, AND COLLAPSE.

SYNCOPE, shock, and collapse are clinical conditions which bear a superficial resemblance to one another, although depending on different causes. Syncope is essentially due to a sudden cerebral anæmia; shock results from a reflex paralysis of the vasomotor centre in the medulla; while the cause of collapse is the abstraction of fluids from the solid tissues and the blood.

Syncope or Fainting.—Syncope is the result of a suddenly-produced anæmia of the brain, from temporary arrest of the heart's action. In surgical practice this condition is usually observed in nervous persons who have been subjected to pain, as in the reduction of a dislocation or the incision of a whitlow; or in those who have rapidly lost a considerable quantity of blood. It may also follow the sudden withdrawal of fluid from a large cavity, as in tapping an abdomen or evacuating an empyema. Fainting sometimes occurs also during the administration of chloroform, especially if there be a tendency to sickness and the patient is not completely under. Its occurrence during an operation is usually attended by the cessation of oozing from the divided vessels in the wound.

Clinical Features.—When a person is about to faint he feels giddy, has surging sounds in the ears, and haziness of vision; he yawns, becomes pale and sick, and a free flow of saliva takes place into the mouth. The pupils dilate; the pulse becomes small and almost imperceptible; the respirations shallow and hurried; consciousness gradually fades away, and he falls in a heap on the floor.

Sometimes vomiting ensues before the patient completely loses consciousness, and the muscular exertion entailed may ward off the actual faint. This is frequently seen in threatened syncopal attacks during chloroform administration.

Recovery begins in a few seconds, the patient sighing or gasping, or, it may be, vomiting; the strength of the pulse gradually increases, and consciousness slowly returns. In some cases, however, syncope is fatal.

Treatment.—The head should at once be lowered—in imitation of nature's method—to encourage the flow of blood to the brain, the patient, if necessary, being held up by the heels. All tight clothing, especially round the neck or chest, must be loosened. The heart may be stimulated reflexly by dashing cold water over the face or chest, or by flipping the surface with a wet towel. The application of volatile substances, such as ammonia or smelling-salts, to the nose; the administration by the mouth of sal-volatile, whisky or brandy, and the intra-muscular injection of ether, are the most speedily efficacious remedies. In severe cases the application of hot cloths over the heart, or of the faradic current over the line of the phrenic nerve, just above the clavicle, may be called for.

Shock is a profound lowering of the vital activity following almost immediately on the receipt of some injury in a previously healthy individual.

Various factors are at work in the production of shock. It may be due to intense mental emotion, with or without an associated injury. Even slight injuries to unimportant tissues may be followed by severe shock, but, other things being equal, the more severe the injury and the more vital the organ affected the greater is the shock. Any injury or operation in the region of the perineum, the genital organs, the face, or the mouth, is usually followed by considerable shock. Damage to parts richly supplied with nerves, especially those derived from the sympathetic system, such as the abdominal or thoracic viscera, is usually attended with profound degrees of shock. Loss of blood also increases the severity of shock. Pain is certainly a factor, although in many cases the severity of the shock bears no direct relation to the intensity of the pain. Persons with a highly-strung nervous system suffer more from shock than do those of a more phlegmatic temperament. Shock is always a risk to be reckoned with in operations on young children; for while many suffer little from shock even after severe operations, others, with much less cause, succumb to it.

When the injured person's mind is absorbed with other matters than his own condition,—as, for example, during the heat of a battle or in the excitement of a railway accident or a conflagration,—even severe injuries may be unattended by pain or shock at the time, although when the period of excitement is over the severity of the shock is all the greater. The same thing is observed in persons injured while under the influence of alcohol.

Pathology.—The explanation of shock which most satisfactorily falls in with the clinical phenomena is that the symptoms result from a reflex paralysis of the vasomotor centre in the medulla, whereby the vascular tone, particularly that of the arteries, is lessened and the blood pressure falls. Most of the blood leaves the arteries and collects in the large venous trunks, especially those of the abdomen. There is thus produced an anæmia of the brain and of the superficial parts of the body. At the same time the right side of the heart becomes overloaded, and impeded in its action.

Clinical Features.—The patient is in a state of great prostration. He is roused from his condition of indifference with difficulty, but answers questions intelligently, if only in a whisper. The face is pale, beads of sweat stand out on the brow, the features are drawn, the eyes sunken, and the cheeks hollow. The lips and ears are livid; the skin of the body of a greyish colour, and cold and clammy. The pulse is rapid, fluttering, and often all but imperceptible at the wrist; the respiration is irregular, shallow, and sighing; and the temperature may fall to 96° F. or even lower. The mouth and tongue are parched, and the patient complains of thirst. There is little sensibility to pain, so that operations may be performed during shock under very mild anæsthesia.

Except in very severe cases, shock tends towards recovery, the *reaction*, as it is called, being often ushered in by vomiting. The pulse becomes full and bounding; the respiration deeper and more regular; the temperature rises to 100° F. or higher; the patient begins to take notice of his surroundings, and may complain of pain.

In certain cases the symptoms of shock so closely resemble those resulting from septic absorption that it is difficult, if not impossible, to distinguish between them, and there can be little doubt that many deaths have been attributed to shock which were really due to acute septicæmia. The conditions formerly known as "delayed shock" and "prostration with excitement" are now generally recognised to be due to septic absorption.

Question of Operating during Shock.—Most authorities agree that operations should only be undertaken during profound shock when they are imperatively demanded for the arrest of hæmorrhage, the prevention of septic infection of serous cavities, or the relief of pain which is producing or intensifying the condition. This question will be discussed in greater detail later.

Prevention of Operation Shock.—About half an hour before a prolonged and severe operation, the patient should receive a nutrient enema of brandy and peptonised meat juice, and a hypodermic injection of $\frac{1}{20}$ grain of strychnine. The operating-room must be warm,—not less than 70° F.,—and the patient should be wrapped in cotton wool and blankets, and surrounded by hot-bottles. All lotions used must be warm (100° F.): and the operation should be completed as speedily and as bloodlessly as possible. In prolonged operations further injections of $\frac{1}{10}$ grain of strychnine may be given.

Treatment.—A patient suffering from shock should be placed in the recumbent position, and the foot of the bed raised to facilitate the return circulation in the large veins, and so increase the flow of blood to the brain. His bed should be placed near a large fire, and the patient himself surrounded by cotton wool and blankets, and hot-bottles. If the patient has lost much blood, the limbs should be wrapped in cotton wool and firmly bandaged from below upwards, to conserve as much of the circulating blood as possible in the trunk and head. If he can swallow, stimulating drinks such as hot coffee, hot wine or whisky should be given; if not, subcutaneous injections of ether (20 to 30 minims), brandy, digitalin ($\frac{1}{100}$ grain), or, best of all, strychnine ($\frac{1}{60}$ to $\frac{1}{30}$ grain), may be administered. Enemata containing stimulants may also be given.

The intra-venous or intra-cellular injection of normal saline solution (one dram of sodium chloride to a pint of boiled water) at a temperature of about 105° F. is most useful where much blood has been lost. Two or three pints may be injected into the veins, or smaller quantities under the skin. Saline fluids injected into the rectum are absorbed more slowly.

The extreme thirst of which the patient so often complains is best met by giving small quantities of warm water by the mouth, or by the injection of four or five ounces of warm water into the rectum. Ice only relieves thirst for a short time, and as it is liable to induce flatulence should be avoided, especially in abdominal cases. Dryness of the tongue may be relieved by swabbing the mouth with a mixture of glycerine and lemon juice.

If severe pain after operation calls for the use of morphin, $\frac{1}{120}$ grain of atropin should be added to avoid the depressing effect of the opiate.

Artificial respiration may be useful in tiding a patient over the critical period of shock.

Collapse is a clinical condition which comes on more insidiously than shock, and which does not attain its maximum degree of severity for several hours. It is met with in the course of severe illnesses, especially such as are associated with the loss of large quantities of fluid from the body—for example, by severe diarrhœa, notably in Asiatic cholera; by copious vomiting; or by profuse sweating, as in some cases of heat stroke.

Collapse often follows upon shock—for example, in intestinal perforations, or after abdominal operations complicated with peritonitis, especially if there be vomiting, as in cases of obstruction high up in the intestine. The symptoms of collapse are aggravated if septic absorption be superadded to the loss of fluid.

Severe degrees of collapse follow any sudden and profuse loss of blood.

The *clinical features* of this condition are practically the same as those of shock; and it is treated on the same lines. It is seldom recovered from.

Delirium in Surgical Patients.

Delirium is a temporary disturbance of mind which occurs in the course of certain diseases, and sometimes after injuries. It is to be looked upon as a serious and dangerous complication.

The causes of delirium in surgical patients are numerous, and it is not always easy in a given case to discover the cause. Thus it may be associated with any of the acute pyogenic infections, with erysipelas, especially when it affects the head or face, and with chronic septic diseases of the urinary organs. In the various forms of meningitis, and in some cases of injury to the head, it is common. It is also met with after severe hæmorrhage, and in cases of poisoning by iodoform, chloroform, morphin, cocain, or alcohol. Lastly, delirium may be an evidence of true insanity.

It may assume the form of excitement, of dementia, or of melancholia; and the symptoms are usually worse during the night. Incoherent muttering regarding past incidents or occupations or absent friends is a common manifestation of the condition.

Delirium Tremens is seen in persons addicted to alcohol who, as a result of accident or operation, are suddenly compelled to lie in bed for some time. Although oftenest met with in habitual drunkards or chronic tipplers, it is by no means uncommon in moderate drinkers, and has even been seen in children who have been supplied with alcohol.

Clinical Features.—The delirium, which has been aptly described as being of a "busy" character, usually first manifests itself within a few days of the patient being laid up. For two or three days he refuses food, is depressed, suspicious, sleepless and restless, desiring to be allowed out of bed. Then he begins to mutter incoherently, to pull off the bedclothes, and to attempt to rise. There is general muscular tremor, most marked in the tongue, the lips, and the hands. The patient imagines that he sees all sorts of horrible beings around him, and is sometimes greatly distressed because of rats, mice, beetles, or snakes which he fancies are crawling over him. The pulse is soft, rapid, and compressible; the temperature is only moderately raised (100°-101° F.), and as a rule there is profuse sweating. The digestion is markedly impaired, and there is often vomiting. Patients in this condition are peculiarly insusceptible to pain, and may even walk about with a fractured leg without apparent discomfort.

In most cases the symptoms begin to pass off in three or four days; the patient sleeps, the hallucinations and tremors cease, and he gradually recovers. In other cases the temperature rises, the pulse becomes running, and death results from exhaustion.

The main indication in *treatment* is to secure sleep, by the administration of bromides, chloral, trional, paraldehyde, or sulphonal. In some cases hyoscin injected hypodermically has been found useful. Morphin must be used with great caution. At the same time the patient must be encouraged to take plenty of easily-digested fluid food; the quantity being supplemented by nutrient enemata if necessary.

In the early stage a brisk mercurial purge is often of great value. Alcohol should be withheld entirely, unless failing of the pulse strongly indicates its use, and then it should be given in the food.

Delirious patients must be constantly watched by a trained attendant or other competent person, lest they get out of bed and do harm to themselves. Mechanical restraint is often necessary, but must be avoided if possible, as it is apt to increase the excitement and exhaust the patient. On account of the extreme restlessness, there is often great difficulty in carrying out the proper treatment of the primary surgical condition, and considerable modifications in splints and other appliances are often rendered necessary.

A form of delirium, sometimes spoken of as **Traumatic Delirium**, may follow on severe injuries or operations in persons of neurotic temperament, or in persons whose nervous system is exhausted by overwork. It is met with apart from alcoholic intemperance. This form of delirium seems to be specially prone to ensue on operations on the face, the thyroid gland, or on the genito-urinary organs. The symptoms appear in from two to five days after the operation, and take the form of restlessness, sleeplessness, low incoherent muttering, and picking at the bed-clothes. It is not necessarily attended by fever or by muscular tremors. The patient may show hysterical symptoms. This condition is probably to be regarded as a form of true insanity, and the patient may become maniacal or melancholic.

The *treatment* is carried out on the same lines as that of delirium tremens.

Fat Embolism.—After various injuries and operations, but especially such as implicate the marrow of long bones—for example, comminuted fractures, osteotomies, resections of joints, or the forcible correction of deformities—fluid fat may enter the circulation in variable quantity. In the vast majority of cases no ill effects follow, but when the quantity is large or when the absorption is long-continued certain symptoms ensue. These are mostly referable to the lungs and brain. They may come on immediately, but as a rule do not do so for two or three days.

In the lungs the fat collects in the minute blood-vessels and produces venous congestion and œdema. Dyspnœa, with cyanosis, a persistent cough and frothy or blood-stained sputum, a feeble pulse and low temperature are the chief symptoms. Pneumonia frequently ensues.

When the fat lodges in the capillaries of the brain the pulse becomes small, rapid, and irregular, delirium followed by coma ensues, and the condition is usually rapidly fatal.

Fat is usually to be detected in the urine, even in mild cases. In fatal cases there are usually other complications present.

The *treatment* is entirely symptomatic.

CHAPTER XIV.

THE BLOOD-VESSELS.

Anatomy—INJURIES OF ARTERIES: *Varieties*—INJURIES OF VEINS: *Air Embolism*—Repair of Blood-vessels and natural arrest of hæmorrhage—HÆMORRHAGE: *Varieties; Prevention; Arrest*—Constitutional effects of hæmorrhage—Hæmophilia—DISEASES OF BLOOD-VESSELS: Thrombosis; Embolism—Arteritis: *Varieties; Atheroma*—Thrombo-phlebitis—Phlebitis: *Varieties*—VARIX—ANGIOMATA—Nævus: *Varieties; Electrolysis*—Cirsoid Aneurysm—ANEURYSM: *Varieties; Methods of Treatment*—ANEURYSMS OF INDIVIDUAL ARTERIES.

Surgical Anatomy.—An *artery* has three coats: an internal coat—the *tunica intima*—made up of a single layer of endothelial cells lining the lumen, outside of which is a layer of delicate connective tissue, and still further out a dense tissue composed of elastic fibres arranged longitudinally which constitutes the internal elastic lamina. The tunica intima is easily ruptured. The middle coat or *tunica media* consists of non-striped muscular fibres arranged for the most part concentrically round the vessel. In this coat also there is a considerable proportion of elastic tissue, especially in the larger vessels. The thickness of the vessel wall depends chiefly on the development of the muscular coat. The external coat or *tunica adventitia* is composed of fibrous tissue containing—especially in vessels of medium calibre—some yellow elastic fibres in its deeper layers.

In most parts of the body the arteries lie in a sheath of connective tissue, from which fine fibrous processes pass to the tunica adventitia. The connection, however, is not a close one, and the artery when divided transversely is capable of retracting for a considerable distance within its sheath. In some of the larger arteries the sheath assumes the form of a definite membrane.

The arteries are nourished by small vessels—the *vasa vasorum*—which ramify chiefly in the outer coat. They are also well supplied with nerves which regulate the size of the lumen by inducing contraction or relaxation of the muscular coat.

The *veins* are constructed on the same general plan as the arteries, the individual coats, however, being thinner. The inner coat is less easily ruptured, and the middle coat contains a smaller proportion of muscular tissue. In one important point veins differ structurally from arteries—namely, in being provided with valves which prevent reflux of the blood. These valves are composed of semilunar folds of the tunica intima strengthened by an addition of connective tissue. Each valve usually consists of two semilunar flaps attached to opposite sides of the vessel wall, each flap having a small sinus on its cardiac side. The distension of these sinuses with blood closes the valve and prevents regurgitation. Valves are absent from the superior and inferior venæ cavæ, the portal vein and its tributaries, the hepatic, renal, uterine, and spermatic veins, and from the veins in the lower part of the rectum. They are ill-developed or absent also in the iliac and common femoral veins—a fact which has an important bearing on the production of varix in the veins of the lower extremity.

The wall of *capillaries* consists of a single layer of endothelial cells.

INJURIES OF ARTERIES.

The following description of the injuries of arteries refers entirely to the larger, named trunks. The injuries of smaller, unnamed vessels are included in the consideration of contusions and wounds.

The injuries to which the larger arteries are liable are: contusion, subcutaneous rupture, laceration with an open wound, and punctured, incised, and gunshot wounds.

Contusion.—An artery may be contused by a blow or crush, or by the oblique impact of a bullet. Such injuries are of little clinical interest, because when subcutaneous they cannot be diagnosed with certainty, and even in the presence of an open wound their existence is largely a matter of conjecture. The bruising of the vessel wall, especially if atheroma be present, may result in the formation of a thrombus which may occlude the lumen temporarily or even permanently, and in rare cases lead to gangrene. A simple contusion, however, is rarely if ever followed by the formation of an aneurysm.

Subcutaneous Rupture.—An artery may be ruptured subcutaneously either by a blow or crush of the limb, or by the displaced fragment of a broken bone or a separated epiphysis. This injury has been produced during attempts to reduce dislocations, especially those of old standing at the shoulder-joint. It is most liable to occur when the vessels are atheromatous. The rupture may be incomplete or complete.

In the majority of cases it is *incomplete*—the inner and middle coats being torn, while the outer coat remains intact. The middle coat contracts and retracts, and the internal, because of its elasticity, curls up in the interior of the vessel, forming a valvular obstruction to the blood-flow. In most cases this results in the formation of a thrombus which occludes the vessel. In some cases the blood pressure gradually distends the injured segment of the vessel wall and produces an aneurysm.

Clinical Features.—The pulsation in the vessels beyond the seat of rupture is almost always arrested—for a time at least—owing to the occlusion of the vessel. If the pulsation returns within a week of the injury the presumption is that the occlusion was due to pressure from without—for example, by hæmorrhage into the sheath, or the pressure of a fragment of bone. In cases of rupture the pulsation seldom returns within five or six weeks of the injury, if indeed it is not permanently arrested. A good collateral circulation, however, is rapidly established, so that although for a few days the limb may be colder than its fellow, the vascularity is soon restored and the nutrition maintained. Temporary loss of power usually accompanies the coldness of the limb.

In cases of incomplete rupture the indications for *treatment* are to promote the restoration of the circulation, and to prevent septic infection of the devitalised segment of the limb beyond the rupture. The skin of the parts supplied by the damaged artery must first be thoroughly purified. The limb is then wrapped in cotton wool to conserve its heat, and elevated to such an extent as to promote the venous return without at the same time unduly interfering with the inflow of blood. To regulate the balance of the circulation requires careful adjustment of the limb, and constant supervision is necessary.

In the majority of cases of incomplete rupture this expectant treatment yields satisfactory results. If gangrene threatens, however, amputation at the level of the seat of rupture is called for.

In more severe cases the rupture is *complete*—all the coats of the vessel being torn across, so that the blood escapes into the surrounding tissues. This degree of damage to the artery is usually associated with tearing of muscles and ligaments, and is best illustrated by those cases in which the popliteal artery is ruptured in fracture of the femur, or the axillary or brachial artery in fractures of the humerus or dislocations of the shoulder.

In addition to the *clinical features* associated with incomplete rupture, a tense and excessively painful swelling rapidly appears in the region of the injury, and where the cellular tissue is loose it may attain a considerable size. While this swelling is forming it may pulsate. In some cases the bleeding does not take place till some hours after the injury, and comes on during the period of reaction from shock. The pressure of the effused blood occludes the veins and leads to marked congestion and œdema of the limb beyond. The interference with the circulation may be so great that gangrene ensues. If no complications supervene the swelling subsides, and recovery may be complete in six or eight weeks.

Even in cases of complete rupture expectant treatment has in many cases yielded satisfactory results. In some cases it may be safer to expose the injured vessel, and, after clearing away the clots, to apply a ligature above and below the rupture. This should always be done if the extravasation is great or if the skin threatens to give way. Amputation is called for if gangrene ensues.

Laceration of Arteries associated with an Open Wound.—Laceration of large arteries is a common complication of severe machinery and railway accidents. The violence being usually of a tearing, twisting, or crushing nature, such injuries are seldom associated with much hæmorrhage, as torn or crushed vessels quickly become occluded by contraction and retraction of their coats and by the formation of a clot. A whole limb even may be completely avulsed from the body with comparatively little loss of blood. The great risk in such cases is secondary hæmorrhage resulting from septic infection.

The *treatment* is that applicable to all infected wounds, with, in addition, the ligation of the lacerated vessels.

Punctured wounds of blood-vessels may result from stabs, or they may be accidentally inflicted by the surgeon in the course of an operation.

The division of the coats of the vessel being incomplete, the natural hæmostasis which results from curling up of the intima and contraction of the media fails to take place, and bleeding goes on externally and into the surrounding tissues. If the sheath of the vessel be not widely damaged, the gradually increasing tension of the extravasated blood retained within it may ultimately arrest the escape from the vessel. A clot then forms between the lips of the wound in the vessel wall and projects for a short distance into the lumen, without, however, materially interfering with the flow through the vessel. The organisation of this clot may result in the healing of the wound in the vessel wall.

In other cases the blood escapes beyond the sheath and infiltrates the surrounding tissues, and a traumatic aneurysm results. Secondary hæmorrhage may result if the wound become septic.

The *treatment* consists in enlarging the external wound sufficiently to enable it to be purified, and to permit of the damaged vessel being ligatured above and below the puncture. In some cases it may be possible to suture the opening in the vessel wall. When circumstances prevent this treatment being carried out, the bleeding may be arrested by making firm pressure over the wound with a pad. This procedure, however, is liable to be followed by the formation of a traumatic aneurysm.

Incised Wounds.—We here refer only to such incised wounds as partially divide the vessel wall.

Longitudinal incised wounds show little tendency to gape, and are, therefore, not attended with much bleeding. They usually heal rapidly, but, like punctured wounds, are liable to be followed by the formation of a traumatic aneurysm.

When the incision in the vessel wall is oblique or transverse, however, the retraction of the muscular coat causes the opening to gape, with the result that there is profuse hæmorrhage, which, even in comparatively small arteries, may prove dangerous. When the associated wound in the soft parts is valvular a traumatic aneurysm may develop.

An incompletely divided artery should be ligatured above and below the wound and divided between the ligatures. Large trunks—such as the external iliac, the femoral, the common carotid, the brachial, and the popliteal—have been successfully sutured after having been partially divided, usually in the course of an operation. Fine silk or catgut stitches are passed through the adventitia and media after the method of Lembert, a thin, round needle being employed. Part of the sheath of the vessel or of an adjacent fascia should be stitched over the line of sutures in the vessel wall. If septic infection has been excluded there is little risk of thrombosis or secondary hæmorrhage.

Gunshot wounds of blood-vessels have been already referred to (p. 214).

INJURIES OF VEINS.

Veins are subject to the same forms of injury as arteries, and the results are in most respects alike in both, such variations as occur being dependent partly on the difference in their anatomical structure, and partly on the conditions of the circulation through them.

Subcutaneous rupture of veins occurs under the same conditions as the corresponding injury of arteries, and more particularly in association with fractures and in the reduction of dislocations. The veins most commonly ruptured are the popliteal, the axillary, the femoral, and the subclavian. On account of the smaller amount of elastic and muscular tissue in a vein, the contraction and retraction of its walls is less than in an artery, and so bleeding may continue for a much longer period. On the other hand, owing to the lower blood pressure in a vein the outflow goes on more slowly, and the gradually increasing pressure produced by the extravasated blood is usually sufficient to arrest the hæmorrhage before it has become serious. As an aid in diagnosing the source of the bleeding, it should be remembered that the rupture of a vein does not affect the pulsation in the limb beyond. The risks are practically the same as when an artery is ruptured, and the treatment is carried out on the same lines, but in the case of veins it is seldom necessary to operate for the purpose of applying a ligature.

Wounds of veins—punctured and incised—frequently occur in the course of surgical operations; for example, in the removal of tumours or diseased glands from the neck, the axilla, or the groin. They are also met with as a result of accidental stabs and of suicidal or homicidal injuries. The hæmorrhage from a large vein so damaged is usually profuse, but owing to the comparatively low blood pressure is more readily controlled by external pressure than that from an artery. When a vein is merely punctured, the bleeding may be arrested either by applying firm pressure with a pad of gauze, or by lateral ligature—that is, picking up the margins of the rent in the wall and securing them with a ligature without occluding the lumen. It is sometimes possible to suture the opening in the wall of the vein. This does not result in obliteration of the lumen, nor does a thrombus necessarily form.

Simultaneous injuries of arteries and veins are usually produced accidentally by stabs, cuts, or bullets, and are often attended with profuse hæmorrhage. In the limbs the risk of gangrene is materially increased when both the artery and the vein are divided, and gangrene is especially liable to ensue if the wound become infected. Punctured and gunshot wounds implicating both vessels are very liable to be followed by the development of arterio-venous aneurysm.

In the region of the neck air may be sucked into an open vein, giving rise to air embolism.

Entrance of Air into Veins—Air Embolism.—This serious, though fortunately rare, accident is apt to occur in the course of operations in the region of the thorax, neck, or axilla, if a large vein is opened and fails to collapse on account of the rigidity of its walls, its incorporation in a dense fascia, or from traction being made upon it. If a vein be thus held open the negative pressure in the vessel during inspiration sucks air into the right side of the heart. This is accompanied by a peculiar hissing or gurgling sound, and with the next expiration some frothy blood leaves the wound in the vessel wall. The patient instantly becomes pale, the pupils dilate, respiration becomes laboured, and, although the heart may continue to beat forcibly, the peripheral pulse is weak, and may even be imperceptible. On auscultating the heart a churning sound may be heard. Death may result in a few minutes; or the heart may slowly regain its power and recovery take place.

These symptoms have been attributed (1) to the collection of air in the right side of the heart, so that the right ventricle has no blood on which to contract, and the pulmonary circulation is therefore stopped; (2) to the passage of air into the pulmonary vessels (*air embolism*), interfering with the circulation in the lungs and preventing the entrance of fresh blood into the left side of the heart; and (3) to the passage of air emboli to the cerebral blood-vessels.

Prevention.—In all operations in the "dangerous area"—as the region of the root of the neck is called in this connection—great care must be taken not to notch or cut across any vein before it has been secured by forceps, and to apply ligatures securely and at once. Deep wounds in this region should be kept filled with an aseptic fluid, such as normal salt solution. Immediately a cut is recognised in a vein, a finger should be placed over the vein on the cardiac side of the wound, and kept there until the vessel is secured by forceps and ligatured.

Treatment.—Little can be done after the air has actually entered the vein beyond endeavouring to keep up the heart's action by hypodermic injections of ether or strychnine, alcoholic enemata, and mustard or hot cloths over the chest. The head at the same time should be lowered to prevent syncope. Attempts to withdraw the air by suction, and the employment of artificial respiration have proved futile, and are, by some, considered dangerous.

Repair of Blood-Vessels, and the Natural Arrest of Hæmorrhage.

These processes are so intimately related to one another that it is advisable to consider them together.

(*a*) When the wall of an artery is *partially* torn, or punctured, it may be repaired by the organisation and subsequent conversion into scar tissue of the clot which forms in the gap. This cicatrix in the vessel wall, however, is liable subsequently to be stretched by the blood pressure and to become the starting-point of a traumatic aneurysm.

(*b*) When an artery is *completely* divided the circular fibres of the muscular coat contract, and so the lumen of the cut ends is diminished. At the same time the vessel retracts within its sheath, in virtue of the recoil of the elastic elements in its walls. The tunica intima curls up in the interior of the vessel, and the tunica adventitia collapses over the cut ends. The blood which escapes from the injured vessel fills the interstices of the tissues, and, coagulating, forms a clot which temporarily arrests the bleeding. That part of the clot which lies between the divided ends of the vessel and in the cellular tissue outside is known as the *external clot*, while the portion which projects into the lumen of the vessel is known as the *internal clot*. The internal clot usually extends into the vessel as far as the nearest collateral branch. These processes constitute what is known as the "temporary arrest of hæmorrhage," which, it will be observed, is effected by the contraction and retraction of the divided artery and by the formation of a clot. The "permanent arrest" takes place by the transformation of this clot into scar tissue. The internal clot plays the most important part in the process: it becomes invaded by leucocytes and proliferating endothelial and connective-tissue cells, and new blood-vessels permeate the mass forming granulation tissue. This is ultimately replaced by cicatricial fibrous tissue, which permanently occludes the end of the vessel. Concurrently and by the same process the external clot is converted into scar tissue.

Repair of Veins.—The process of repair in veins is the same as that in arteries, but the thrombosed area may again become canalised and the circulation through the vessel be re-established.

Conditions which influence the Natural Arrest of Hæmorrhage.—It has already been mentioned that contusion or laceration of a blood-vessel promotes the natural arrest of hæmorrhage by favouring the formation of clots on the damaged portions of the vessel wall. The occurrence of syncope or of profound shock also helps to stop bleeding by reducing the force of the heart's action.

On the other hand, there are various conditions which retard the natural arrest. When, for example, a vessel is only partially divided, the contraction and retraction of the muscular coat, instead of diminishing the calibre of the artery, open up the hole in its wall and allow of free bleeding. By completing the division of the vessel under these circumstances the bleeding can often be arrested. In certain situations also the arteries are so intimately connected with their sheaths that they are unable to retract and contract when cut across,—for example, in the scalp, in the penis, and in bones,—and copious bleeding may take place from comparatively small vessels. This inability of the vessels to contract and retract occurs also in inflamed and œdematous parts and in scar tissue. Arteries divided in the substance of a muscle also sometimes bleed unduly. Any increase in the force of the heart's action, such as may result from exertion, excitement, or over-stimulation, also prevents the natural arrest of bleeding. Hæmophilia will be referred to later.

In course of time the collateral branches of the vessel above and below the level of section become enlarged and their intercommunication becomes more free, so that even when large trunks have been divided the vascular supply of the parts beyond is completely restored. This is known as the development of the collateral circulation.

(*c*) *Ligature of a Vessel in its Continuity.*—When a ligature is applied to an artery it should be pulled sufficiently tight to occlude the lumen without causing rupture of any of its coats. It often happens, however, that the compression causes a rupture of the inner and middle coats, so that only the adventitia remains in the grasp of the ligature. While this weakens the wall of the vessel, it has the advantage of hastening coagulation, by bringing the blood into contact with damaged tissue. Whether the inner and middle coats be ruptured or not, blood coagulates both above and below the ligature, the proximal clot being longer and broader than that on the distal side. In small arteries these clots extend as far as the nearest collateral branch, but in the larger trunks their length is variable. The permanent occlusion of those portions of the vessel occupied by clot is brought about by the formation of granulation tissue, and its replacement by cicatricial tissue. In this process the coagulum only plays a passive *rôle* by forming a scaffolding on which the granulations are built up. The ligature which surrounds the vessel, and the elements of the clot are ultimately absorbed.

(*d*) In a vessel *ligatured at its cut end*,—as, for example, in an amputation stump,—the regenerative process is practically the same as when it is ligatured in its continuity. The ligature

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usually tears the internal and middle coats, and so pulls the adventitial coat together. The ligature and the small portion of vessel beyond it are subsequently absorbed.

HÆMORRHAGE.

Various terms are employed in relation to hæmorrhage according to its seat, its origin, the time at which it occurs, and other circumstances.

The term *external hæmorrhage* is employed when the blood escapes directly to the surface; when the bleeding takes place into the tissues or into a cavity it is spoken of as *internal.* The blood may infiltrate the connective tissue of the skin or of deeper parts, constituting an *extravasation* of blood; or it may collect in a definite space or cavity and form a *hæmatoma.*

The coughing up of blood from the lungs is known as *hæmoptysis;* vomiting of blood from the stomach as *hæmatemesis;* the passage of stools black from blood as *melæna*, and the passage of bloody urine as *hæmaturia.*

Such terms as cerebral, pulmonary, renal, uterine, applied to hæmorrhage, obviously indicate the organ which is the seat of the bleeding.

Hæmorrhage is known as arterial, venous, or capillary, according to the nature of the vessel from which it takes place.

In *arterial* hæmorrhage the blood is bright red in colour, and escapes from the cardiac end of the divided vessel in forcible jets synchronously with the systole of the heart. In very vascular tissues—for example, the face—both ends of a divided artery bleed freely. The blood flowing from an artery may be dark in colour if the patient's respiration is impeded. The flow is sometimes continuous and not in jets when the heart's action is weak and the blood tension low, or when the bleeding takes place into a deep wound and not directly onto the free surface.

Venous bleeding is not pulsatile, but occurs in a continuous stream, which, although both ends often bleed, is most copious from the distal end of the vessel. The blood is dark red under ordinary conditions, but may be purplish, or even black, if the patient is becoming asphyxiated. When one of the large veins in the neck is wounded the effects of respiration produce a rise and fall in the blood-stream which may resemble arterial pulsation. Bleeding from the cardiac end of a varicose vein may be very copious.

In *capillary* hæmorrhage red blood escapes from numerous points on the surface of the wound in a slow, steady ooze. This form of bleeding is often serious after operations in which an elastic tourniquet has been employed, and in bleeders.

In relation to the time at which it occurs, hæmorrhage is spoken of as primary, reactionary, and secondary.

Primary hæmorrhage is that which immediately follows a wound of a blood-vessel.

Treatment.—It is convenient to consider separately the treatment of primary hæmorrhage, as it occurs in an accidentally-inflicted wound, and in the course of a surgical operation.

Surgical Arrest of Accidental Hæmorrhage.—In attempting to stop bleeding it is well to bear in mind the factors which promote its spontaneous arrest, and to endeavour, as far as possible, to imitate the natural process. The first step in arresting bleeding from a wound is to clear away all clots which may have formed, as these obscure the bleeding point. If the hæmorrhage is from a partially-divided vessel, this should be completely cut across to enable its walls to contract and retract, and to facilitate the application of forceps and ligatures.

As the formation of a coagulum is favoured by a weak condition of the circulation and by a low blood pressure, active stimulation of the patient should be avoided, and absolute rest ensured. Elevation of the bleeding part is indicated, especially in the case of a limb, and flexion of the joint on the proximal side of the bleeding-point—knee or elbow—is often of value.

When the bleeding is profuse, further measures must be taken. The most efficient means of temporarily controlling profuse hæmorrhage is by pressure applied with the finger, or with a pad of gauze, directly over the bleeding point. While this is maintained an assistant makes digital pressure, or applies a tourniquet, over the main vessel of the limb on the proximal side of the bleeding point. A useful emergency tourniquet may be improvised by folding a large handkerchief *en cravatte*, with a cork or piece of wood in the fold to act as a pad. The handkerchief is applied round the limb, with the pad over the main artery, and the ends knotted on the outer aspect of the limb. With a strong piece of wood the handkerchief is wound up like a Spanish windlass, until sufficient pressure is exerted to arrest the bleeding. The hæmorrhage being thus controlled, the surgeon proceeds to apply a ligature to each end of the bleeding vessels in the way presently to be described.

Hæmorrhage in Surgical Operations.—The management of the hæmorrhage which accompanies a surgical operation includes (*a*) preventive measures, and (*b*) the arrest of the bleeding.

Prevention of Hæmorrhage.—The most convenient and certain means of preventing hæmorrhage—say in an amputation—is by the use of some form of *tourniquet*, such as the elastic tubing of Esmarch or of Foulis, or an elastic bandage, or the screw tourniquet of Petit. Before applying any of these it is advisable to empty the limb of blood. This is best done after the manner suggested by Lord Lister. The limb is held vertical for three or four minutes; the veins are thus emptied by gravitation and they collapse, and as a physiological result of this the arteries reflexly contract, so that the quantity of blood entering the limb is reduced to a minimum. With the limb still elevated the tourniquet is firmly applied, a part of the limb being selected where the vessel can be pressed directly against a bone, and where there is no risk of exerting injurious pressure on important nerve trunks. To protect the skin the tourniquet should be applied over a layer of lint. The first turns of the tourniquet must be rapidly and tightly applied to arrest completely the arterial flow. Unless this is done the veins only are obstructed and the limb becomes congested. In the inferior extremity the best place to apply a tourniquet is the lower third of the thigh, and in the superior, the middle of the upper arm. This "bloodless method" of operating is subject to the objection that, owing to the vasomotor paralysis of the smaller vessels, the bleeding which takes place after the removal of the tourniquet is often profuse.

To obviate this disadvantage, many surgeons rely upon *digital compression* of the main vessel supplying the limb. The amount of blood lost immediately may be greater than by the "bloodless method," but the small vessels bleed much less, so that the total loss of blood is probably about equal in the two.

In selecting a point at which to apply digital compression, it is essential that the vessel should be lying over and close to a bone which will furnish the necessary resistance. The following are the more important vessels which lend themselves to digital compression, and the directions in which the pressure should be applied. The common carotid is pressed backward and inward against the transverse process (carotid tubercle) of the sixth cervical vertebra; the temporal against the zygoma in front of the ear; and the facial against the lower jaw at the anterior edge of the masseter muscle.

In the upper extremity the subclavian is pressed against the first rib by making pressure downwards and backwards in the hollow above the clavicle; the axillary and brachial by pressing against the shaft of the humerus.

In the lower extremity the femoral is controlled by pressing in a direction backward and slightly upward against the brim of the pelvis, midway between the symphysis pubis and the anterior superior iliac spine.

The abdominal aorta may be compressed against the bodies of the lumbar vertebræ opposite the umbilicus, if the spine be arched well forwards over a pillow or sand-bag. The best method is that suggested by Macewen, in which the patient's spine is arched forwards by allowing the lower extremities and pelvis to hang over the lower end of the table, while the assistant, standing on a stool, applies his closed fist over the abdominal aorta and compresses it against the vertebral column.

Arrest of Hæmorrhage.—The best means of securing the larger vessels is by ligature. Torsion and forci-pressure are more suitable to small branches. The actual cautery, douching with very hot water, the local application of styptics, and the internal administration of drugs have a limited field of usefulness in the treatment of surgical hæmorrhage.

Ligature.—The divided vessel having been secured with forceps as near to its cut end as possible, a ligature is applied, preferably of some absorbable material such as catgut or kangaroo tendon. Fine silk may be preferred, on account of the greater certainty with which it can be sterilised.

Torsion.—In employing torsion, the end of the vessel is caught with forceps, and the terminal portion twisted round several times. The object is to tear the inner and middle coats of the vessel so that they curl up inside the lumen, while the outer fibrous coat is twisted into a cord which occludes the end of the vessel. This method is seldom employed except for comparatively small vessels, but it is applicable to even the largest arteries.

Forci-pressure.—Bleeding from the smallest arteries and from arterioles can usually be arrested by firmly squeezing them for a few minutes with serrated or grooved artery forceps, such as those of Spencer Wells, Kocher, or Greig-Smith. It is usually found that on the removal of the forceps at the end of the operation no further hæmorrhage takes place.

The actual *cautery* or Paquelin's thermo-cautery is sometimes employed to arrest hæmorrhage. It is used at a dull-red heat, which sears the divided ends of the vessels and so occludes the lumen. A bright-red or a white heat cuts the vessel across without occluding it. The separation of the slough produced by the charring of the tissues is sometimes attended with secondary bleeding.

Profuse capillary oozing may sometimes be arrested by douching the part with sterilised water at a temperature of about 110° F.

Styptics.—The local application of styptics is seldom to be recommended. In the treatment of epistaxis or bleeding from the nose, of hæmorrhage from the socket of an extracted tooth, and sometimes from ulcerating or granulating surfaces, however, styptics are useful. All clots must be removed and the drug applied by means of a pad of gauze directly to the bleeding surface. Adrenalin, turpentine, peroxide of hydrogen, and liquor ferri perchloridi are the most useful drugs for this purpose.

The internal administration of such drugs as ergot and its derivatives, gallic acid, and chloride of calcium is seldom called for.

Reactionary or intermediary hæmorrhage is really a recurrence of primary bleeding. As the name indicates, it occurs during the period of reaction—that is, within the first few hours after an operation or injury. It is due to the increase in the blood pressure which accompanies reaction displacing the clots which occlude the vessels, or causing vessels to bleed which did not bleed during the operation; or it may be due to the slipping of a ligature or to the giving way of a grossly damaged portion of the vessel wall. In certain situations also—for example, in the scrotum—the relaxation of the dartos during the first few hours after operation may lead to reactionary hæmorrhage.

When the bleeding is due to a ligature having slipped from a large vessel, the wound must be opened up and the vessel again secured. As a rule, however, reactionary hæmorrhage takes place from small vessels, and is due to displacement of the occluding clots. In many cases the hæmorrhage is found to stop when the bandages and soaked dressings are removed. Whether this occurs or not, it is usually sufficient in the first instance to apply firm pressure and to elevate the limb. Should the hæmorrhage recur, the wound must be reopened, and forceps or ligatures applied to the bleeding vessels. Douching the wound with hot sterilised water (about 110° F.), and plugging it tightly with sterilised gauze are often successful in arresting capillary oozing from a large surface. The internal administration of morphin sometimes proves useful by keeping the patient quiet.

The term **Secondary Hæmorrhage** refers to bleeding which is due to some interference with the natural process by which an injured vessel is repaired. It is also employed to describe the bleeding which may result from erosion of a blood-vessel—

for example, by an abscess burrowing into it, or by sloughing in the sore throat of scarlet fever, or by the pressure of a drainage-tube. As secondary hæmorrhage is almost invariably the result of septic processes, it is much less frequent now than it was in pre-antiseptic days. In whatever way the infective material reaches the vessel—whether from suppuration in the wound, from the material used for ligature, or from the blood-stream—it produces an inflammatory softening and disintegration of the occluding clot or young fibrous tissue, and of the vessel wall. The bleeding which takes place when the vessel at length gives way may at first be slight and may stop spontaneously. It soon recurs, however, and as the destructive process progresses, the recurrences become more frequent and the flow more abundant, until eventually a profuse, and it may be fatal, hæmorrhage results.

The occurrence of slight hæmorrhages from a suppurating wound in the vicinity of a large blood-vessel is strongly suggestive of secondary hæmorrhage, and should always lead to steps being taken to avoid more serious bleeding, or to deal with it when it occurs. A Petit's screw tourniquet should be loosely applied to the limb above the wound, and the nurse should be instructed to tighten it up in the event of bleeding taking place, and to summon the surgeon without delay. In most cases, however, it is safer to anticipate serious bleeding by operative measures.

Treatment.—If the bleeding is from a moderate-sized vessel, it may be sufficient to wash out the wound with a hot antiseptic lotion, and after sponging it with pure carbolic acid, to plug it tightly with iodoform or double-cyanide gauze. If practicable, the bleeding vessel should be secured by a fresh ligature.

When a large vessel is involved and when the wound is badly infected and sloughing, it is safer to ligature the main vessel through a fresh incision well above the wound. Should this fail to arrest the hæmorrhage, or should the procedure involve the risk of gangrene, it may be necessary to amputate the limb well above the infected area. Gangrene is more likely to follow ligature of the main vessels of the lower than of the upper extremity under these conditions, although we have ourselves ligatured both the external iliac artery and vein for secondary hæmorrhage without inducing gangrene. In situations where proximal ligature is impossible—for example, in the neck, the groin, or the pelvis—firm plugging with antiseptic gauze may be the only treatment available.

Constitutional Effects of Hæmorrhage.—The severity of the symptoms resulting from hæmorrhage depends as much on the rapidity with which the bleeding takes place as on the amount of blood lost. The sudden loss of a large quantity of blood, whether from an open wound or into a serous cavity, — for example, after rupture of the liver or spleen,—is attended with marked pallor of the surface of the body and coldness of the skin, especially of the face, ears, nose, feet, and hands. The skin is moist with a cold, clammy sweat, and beads of perspiration stand out on the forehead. The pulse becomes feeble, soft, and rapid, and the patient feels faint and listless. The temperature is usually subnormal; and the respiration rapid, shallow, and sighing in character. Abnormal visual sensations, such as flashes of light or spots before the eyes, and rushing, buzzing, or ringing sounds in the ears are often complained of. The patient usually suffers from extreme thirst which is very distressing. Syncope often occurs, and may prove fatal.

In extreme cases phenomena which have been aptly described as those of "air hunger" ensue. On account of the small quantity of blood circulating through the body, the tissues are imperfectly oxygenated, and the patient experiences sensations as of suffocation. He is extremely restless, gasps for breath, constantly throws about his arms and bares his chest in the vain attempt to breathe more freely. Faintness and vertigo are marked features. The diminished supply of oxygen to the brain and to the muscles produces muscular twitchings, and sometimes convulsions. Finally, the pupils dilate, the sphincters relax, and death ensues.

It is to be borne in mind that young children stand the loss of blood badly, but that they quickly recover as the regeneration of blood takes place rapidly. In old people also, and especially when they are fat, the loss of blood is badly borne, and the ill-effects last longer, and may even be permanent. Women, on the whole, stand loss of blood better than men, and in them the blood is more rapidly replaced.

Treatment.—The treatment is practically the same as that of shock. The patient should be placed at rest in a warm but well-ventilated room, and the foot of the bed should be elevated. Cardiac stimulants, such as strychnine, alcohol or ether, must be judiciously administered, over-stimulation being carefully avoided. The inhalation of oxygen has been found useful in relieving the more urgent symptoms of dyspnœa.

The blood may be emptied from the limbs into the vessels of the trunk, where it is more needed, by holding them vertically in the air for a few minutes, and then applying a firm elastic bandage over a layer of cotton wool.

Introduction of Fluids into the Circulation.—The most valuable measure for maintaining the circulation, however, is the injection of from one to three pints of ordinary physiological salt solution (a teaspoonful of common salt to a pint of water) into a vein. The solution is sterilised by boiling, and cooled to a temperature of about 100° F. It is best introduced into the median basilic (or other superficial) vein, by means of a small glass or metal nozzle to which is attached three or four feet of rubber tubing with a glass funnel at the end of it. All air is expelled from the apparatus by filling it with fluid before connecting it with the vein. The fluid is allowed to flow slowly into the vein—from twenty to thirty minutes being occupied in the process—the pressure being graduated by raising or lowering the funnel. The tube must constantly be kept filled with fluid to avoid the risk of introducing air into the circulation.

When for any reason it is inexpedient to inject the fluid directly into a vein, equally satisfactory, although less rapidly attained results follow its introduction into the cellular tissue—for example, under the mamma, into the axilla, or under the skin of the back—or into the peritoneal cavity. Repeated injections of one or two pints of saline solution into the rectum also yield satisfactory results.

If the patient can retain fluids taken by the mouth—such as hot coffee, barley water, or soda water—these should be freely given, unless the injury necessitates operative treatment under an anæsthetic.

The injection of blood obtained from a healthy individual is sometimes employed in the treatment of pernicious anæmia and other diseases. As it flows from the vein of the donor, the blood is caught in a warm glass dish, and is kept from coagulating by having added to it a five per cent. solution of phosphate of soda (two ounces of the solution to every six ounces of blood). The mixture is then slowly injected into one of the patient's veins, means being taken to keep it at the body temperature. In addition to the fact that it has no advantage over saline injections, the risk of introducing blood-clots and septic organisms, the more elaborate technique, and the frequent difficulty of obtaining a suitable donor of blood, militate against the employment of this method in the treatment of hæmorrhage.

The direct transfusion of blood from one person to another has been almost entirely superseded by the above methods.

The free administration of fluids by the mouth and a liberal diet of easily digested and readily absorbable food are clearly indicated. Iron, arsenic, and other hæmatinic drugs are also called for.

HÆMOPHILIA.

The term hæmophilia is applied to a peculiar inherited disease which renders the patient liable to serious hæmorrhage from even the most trivial injuries. Those who suffer from the condition are popularly known as "bleeders."

The essential cause of the disease and its true nature are as yet unknown. There is no proof of any structural defect in the blood-vessels, nor has it been demonstrated that there is any alteration in the chemical composition of the blood.

The disease is in a marked degree hereditary, all the branches of an affected family being liable to suffer. Its mode of transmission to individuals, moreover, is very characteristic: the male members of the stock alone suffer from the affection in its typical form, while the tendency is transmitted through the female line. Thus the daughters of a father who is a bleeder, whilst they do not themselves suffer from the disease, transmit the tendency to their male offspring. The sons, on the other hand, neither suffer themselves nor transmit the disease to their children.

Clinical Features.—The disease is met with in boys who are otherwise healthy, and usually manifests itself during the first five years of life. In rare instances profuse hæmorrhage takes place from the umbilical cord. As a rule the first evidence is the occurrence of severe, long-continued, and uncontrollable bleeding from a comparatively slight injury, such as the scratch of a pin, the extraction of a tooth, or a circumcision wound. The blood oozes slowly from the capillaries. At first it appears normal, but after flowing for some days, or it may be weeks, it becomes pale, thin, and watery, and shows less and less tendency to coagulate.

Sometimes the hæmorrhage takes place apparently spontaneously from a mucous surface, such as the gums, the nasal mucous membrane, or the alimentary canal. In other cases the bleeding occurs into the cellular tissue under the skin or mucous membrane, producing large areas of ecchymosis and discoloration. One of the commonest manifestations of the disease is the occurrence of hæmorrhage into the synovial cavities of the large joints, especially the knee, elbow, or hip. The patient suffers repeatedly from such hæmorrhages, the determining injury being often so slight as to have passed unobserved.

There is evidence that the tendency to bleed is greater at some times than at others—in certain cases showing almost a cyclical character—although nothing is known as to the cause of the variation.

After a severe hæmorrhage into the cellular tissue or into a joint, the patient becomes pale and anæmic, the temperature may rise to 102° or 103° F., the pulse become small and rapid, and hæmic murmurs are sometimes developed over the heart and large arteries. The swelling is tense, fluctuating, and hot, and there is considerable pain and tenderness.

In exceptional cases blisters form over the seat of the effusion, or the skin may even slough, and the clinical features may therefore come to simulate closely those of an acute suppurative condition.

The acute symptoms gradually subside, and the effused blood is slowly absorbed, the discoloration of the skin passing through the same series of changes as occurs after an ordinary bruise. Prolonged external hæmorrhage is usually associated with a subnormal temperature. The patients bear the loss of blood remarkably well, and the blood is rapidly regenerated.

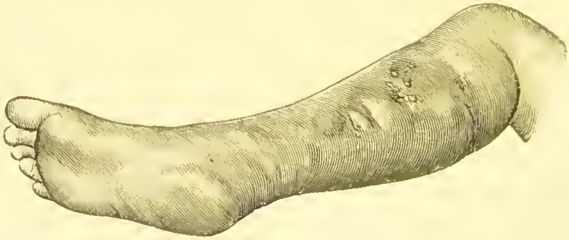

FIG. 44.—Extensive Subcutaneous Effusion in case of Hæmophilia. The condition simulated Acute Osteo-Myelitis of Tibia.

The *diagnosis* is usually easy if the patient or his friends are aware of the family tendency to hæmorrhage and inform the surgeon of it, but they are often very sensitive and reticent regarding the fact, and it may only be elicited after close investigation. Scurvy and purpura are usually excluded with ease. Repeated hæmorrhages into a joint may result in appearances which closely simulate those of tuberculous disease. Recent hæmorrhages into the cellular tissue often present clinical features closely resembling those of acute cellulitis or osteo-myelitis (Fig. 44). A careful examination, however, may reveal superficial bruises on other parts of the body which give a clue to the nature of the condition, and may prevent the disastrous consequences which would follow incision of the swelling.

The *prognosis* is, on the whole, unfavourable, as these patients usually succumb sooner or later to hæmorrhage, although they often survive several very severe attacks. After middle life the tendency to bleed appears to diminish.

Treatment.—As a rule the ordinary styptics and other means of arresting hæmorrhage are of little avail, and in most cases it is only after trying many remedies that the bleeding ceases.

From among the numerous means suggested for treating this disease the following may be mentioned. The application to the bleeding point of gauze soaked in a 1 in 1000 solution of adrenalin has been found beneficial, as has also the use of the blood of a healthy person applied in the same way. The prolonged inhalation of oxygen has recently been recommended as highly efficacious. The oozing may be controlled, temporarily at least, by freezing the part with a spray of ethyl-chloride. One or more subcutaneous injections of gelatin may be given—five ounces of a 2½ per cent. solution of white gelatin in normal salt solution being injected at a temperature of about 100° F. In the prophylaxis of hæmophilia chloride of calcium and extract of thymus gland have also been recommended as having the property of increasing the coagulability of the blood. Their use, however, is attended with risk of thrombosis if the circulation is very weak.

DISEASES OF BLOOD-VESSELS.

The processes known as thrombosis and embolism are so intimately associated with the diseases of blood-vessels that it is convenient to define these terms in the first instance.

Thrombosis.—The term *thrombus* is applied to a clot of blood locally formed in the interior of the heart or of a blood-vessel, and the process by which such a clot is formed is known as *thrombosis*. The essential cause of thrombosis is as yet not thoroughly understood. It would appear, however, that slowing or stagnation of the blood-stream, and interference with the integrity of the lining membrane of the vessel wall, are the most important factors determining the formation of the clot. As a result of either or of both of these factors, the blood-plates and leucocytes adhere to the vessel wall, and as a result of their disintegration a fibrin ferment is set free which determines coagulation and the deposit of fibrin. When the thrombus is formed slowly it is of a greyish-white colour, and, being deposited in successive layers, has a distinctly laminated appearance on section. This is known as a *white thrombus* or laminated clot, and is often met with in the sac of an aneurysm (Fig. 51). When rapidly formed in a vessel in which the blood is almost stagnant—as, for example, in a large varicose vein—the blood coagulates *en masse* and the clot consists of all the elements of the blood and constitutes a *red thrombus.* Sometimes the thrombus is mixed—a red thrombus being deposited on a white one, it may be in alternate layers.

When aseptic a thrombus usually undergoes organisation by the process already described in relation to the repair of injured blood-vessels. On the other hand, it may degenerate and undergo calcification, or a portion of it may become detached and be carried off in the blood-stream as an embolus.

Occasionally a small thrombus situated behind a valve in a varicose vein or in the terminal end of a dilated vein—for example, in a pile—undergoes calcification, becoming converted into a *phlebolith* by the deposit of lime salts in its texture.

When infected with pyogenic bacteria the thrombus becomes converted into pus and a localised abscess may form, or portions of the thrombus may be carried as septic emboli in the circulation to distant parts, where they give rise to secondary foci of suppuration—pyæmic abscesses.

Embolism.—The term *embolus* is applied to any body carried along in the arterial circulation and ultimately impacted in one of the arteries. This occurrence is known as *embolism.* The commonest forms of embolus are portions of thrombi or of fibrinous formations on the valves of the heart, the latter being usually infected with micro-organisms.

Embolism plays an important part in determining one form of gangrene, as has already been described. Septic emboli are the direct cause of the secondary abscesses which occur in pyæmia; and they are sometimes responsible for the formation of aneurysm.

Portions of malignant tumours also may form emboli, and their impaction in the vessels may lead to the development of secondary growths in distant parts of the body.

Fat and air embolism have already been referred to.

ARTERITIS.

Arteritis due to Pyogenic Organisms.—The wall of an artery, like any other tissue, may be the seat of acute pyogenic processes. The infection may take place by direct spread from a focus of suppuration in the vicinity of the artery, from an imperfectly sterilised ligature applied to the vessel, or from the blood-stream in the form of a septic embolus—*embolic arteritis.* The changes characteristic of acute inflammation and suppuration take place in the tissues of the vessel wall, and are attended—especially in the smaller vessels—with the formation of a thrombus in the lumen. The breaking down of the wall of a vessel so affected is the chief cause of secondary hæmorrhage. Sometimes the vessel ruptures into an abscess cavity, and dangerous bleeding may occur when the abscess is opened or allowed to burst.

When the inflammation stops short of suppuration the softening of the vessel wall may lead to aneurysmal dilatation. This occurs in embolic arteritis, and is frequently associated with disease of the valves of the heart. It is not uncommon in children, and explains many of the cases of aneurysm met with in young subjects.

Syphilitic Arteritis.—The inflammation of arteries associated with syphilis results in marked thickening of the tunica intima, whereby the lumen of the vessel becomes greatly narrowed, or, it may be, even obliterated—hence the term *endarteritis obliterans.* The middle coat usually escapes, but the tunica adventitia is generally thickened. These changes are best seen in the smaller vessels of the brain and of the abdominal viscera, and they cause serious interference with the nutrition of the parts supplied by the affected arteries. When they occur in large trunks they are liable to lead to the formation of an aneurysm by diminishing the elasticity of the vessel wall.

Changes in the arterial walls closely resembling those of syphilitic arteritis are sometimes met with in *tuberculous* lesions.

Atheroma.—This name is applied to certain changes which occur in the deeper layers of the tunica intima whereby an increased development of young fibrous tissue takes place. In course of time this new tissue undergoes degeneration—at first usually of a fatty nature, but progressing in the direction of calcification.

When this degeneration ensues, lime salts are deposited in the young fibrous tissue, and calcareous plates or rings form, sometimes over a considerable area of the vessel wall. The endothelium over these plates often disappears, leaving them exposed to the blood-stream, whereby they favour the occurrence of thrombosis.

Changes of a similar kind sometimes occur in the middle coat, the lime salts being deposited among the muscle fibres in concentric rings.

The primary cause of atheroma is not definitely known, but its almost constant occurrence in the aged, to a greater or less degree, suggests that it is of the nature of a senile degeneration.

It is favoured by anything which throws excessive strain on the vessel walls, such as heavy muscular work; by chronic alcoholism and syphilis; or by such general diseases as tend to raise the blood pressure—for example, chronic Bright's disease or gout.

It occurs with greater frequency and with greater severity in men than in women. The large arterial trunks are chiefly affected, and the changes are most marked at the arch of the aorta, opposite the flexures of joints, at the mouths of large branches, and at parts where the vessel lies in contact with bone.

The presence of these calcareous plates in the wall of an artery diminishes its elasticity and favours aneurysmal dilatation. Such a vessel also is liable to be ruptured by external violence and so give rise to traumatic aneurysm. In the smaller vessels atheroma may lead to diminution or even to occlusion of the lumen—a condition which in the limbs predisposes to gangrene. Thrombosis is liable to occur when the plates are exposed in the lumen of the vessel by destruction of the endothelium, and this predisposes to embolism. Atheroma also interferes with the natural arrest of hæmorrhage, and by rendering the vessels brittle, makes it difficult to apply a ligature to them. In advanced cases the accessible arteries—such as the radial, the temporal, or the femoral—may be felt as firm, tortuous cords, which are sometimes so hard that they have been aptly compared to "pipe-stems." The pulse is smaller and less compressible than normal, and the vessel moves bodily with each pulsation. When all the vessels of a limb are affected, the distal parts are cold and wasted, and gangrene is very liable to occur.

Thrombosis in Veins and Thrombo-Phlebitis.—Thrombosis is more common in veins than in arteries, probably because the conditions which favour the formation of thrombi—slowing of the blood-stream and irritation of the endothelium of the vessel wall—are, owing to the conditions of the venous circulation, more readily induced in veins.

Venous thrombosis may occur from purely mechanical causes—as, for example, when the wall of a vein is incised, or the vessel included in a ligature, or when it is bruised or crushed by a fragment of a broken bone or by a bandage too tightly applied. Under these conditions the thrombosis is essentially a reparative process, and has already been considered in relation to the repair of blood-vessels.

In other cases thrombosis is associated with certain constitutional diseases—for example, gout and rheumatism; the endothelium of the veins undergoing changes—possibly the result of irritation by abnormal constituents in the blood—which favour the formation of thrombi. In patients suffering from extreme debility or the cachexia of cancer, also, venous thrombosis is liable to occur.

Under these various conditions the formation of a thrombus is not necessarily associated with the action of bacteria, although in any of them this additional factor may be present.

The most common cause of venous thrombosis, however, is inflammation of the wall of the vein—phlebitis.

Phlebitis.—Various forms of phlebitis are met with clinically, but for practical purposes they may be divided into two groups—one in which there is little or no tendency towards suppuration; the other in which the suppurative element predominates.

The *non-suppurative form* is almost invariably met with in the lower extremity, and usually occurs in patients who are debilitated and anæmic, and who are confined to bed for prolonged periods—for example, during the treatment of fractures of the leg or pelvis, or after operations in the region of the groin or pelvis. During convalescence from such general diseases as typhoid fever or influenza, and in patients suffering from chlorosis or from gout or rheumatism, this form of phlebitis is also liable to occur. It most frequently attacks veins which are varicose. A non-suppurative form of phlebitis frequently occurs in the great longitudinal sinus in patients suffering from extreme debility.

The coats of the vessel become infiltrated with leucocytes and proliferated connective-tissue cells, which gradually invade the thrombus that occupies the lumen. In course of time this thrombus becomes organised and may lead to permanent occlusion of the vein. It may happen that a portion of the thrombus passes into the circulation as an embolus. The cellular tissue surrounding the affected vein usually shares in the inflammation—a condition known as *peri-phlebitis*.

Clinical Features.—The most typical example of this form of phlebitis is that so frequently met with in the internal saphena vein — especially when it is varicose. The condition may follow an injury, or the patient may have been suffering from some illness, or there may be no determining cause ascertainable. The onset of the attack is usually indicated by a sudden and severe pain in the lower limb—sometimes below, sometimes above the knee. This initial pain may be associated with shivering or even with a rigor, and the temperature usually rises one or two degrees. There is marked swelling and tenderness along the line of the affected vein, and the skin over it is a dull-red or purple colour. The swollen vein may be felt as a firm cord, with bead-like enlargements in the position of the valves. The patient experiences a feeling of stiffness and tightness through the limb. There is often considerable œdematous swelling of the leg and foot, especially when the limb is in the dependent position. The acute symptoms pass off in a few days, but the swelling and tenderness of the vein and the œdema of the limb may last for many weeks.

When the deep veins—iliac, femoral, popliteal—are involved there is usually great swelling of the whole limb, which is of a firm, almost "wooden" consistence, and of a pale-white colour. This is most often seen in puerperal women, and is known as *phlegmasia alba dolens*.

The *treatment* consists in placing the patient at absolute rest with the foot of the bed raised on blocks ten or twelve inches high and the limb fixed by sand-bags or splints. It is necessary to avoid handling the parts, lest the clot be disturbed and embolism occur.

Warm antiseptic fomentations (1 in 40 carbolic) covered with a thick layer of cotton wool, and changed at long intervals,—say twice in the twenty-four hours,—are useful in soothing the pain and reducing the swelling. To avoid frequent movement of the limb the dressings should be kept in position by means of a many-tailed rather than a roller bandage.

When the danger of embolism is past, douching and gentle massage may be employed to disperse the œdema; and when the patient gets up he should wear a supporting elastic bandage.

The general treatment varies with the condition of the patient. When the phlebitis is a complication of varicose veins, these should be treated by operation, as recurrence of the inflammation is liable to take place.

The *suppurative* form usually begins as a peri-phlebitis arising in connection with some septic focus in the adjacent tissues. The elements of the vessel wall are destroyed by suppuration, and the thrombus in its lumen soon becomes infected with pyogenic bacteria and undergoes suppuration. In some cases the organisms reach the thrombus directly from the blood-stream, in others from infected ligatures or instruments—as, for example, in operations for varicose veins or hæmorrhoids.

Portions of the softened thrombus are very liable to become detached and to enter the circulating blood, in which they are carried as septic emboli. These may lodge in distant parts and give rise to secondary foci of suppuration—pyæmic abscesses.

Clinical Features.—Suppurative phlebitis is most frequently met with in the lateral sinus as a sequel to chronic suppuration in the mastoid antrum, but it also occurs in relation to the peripheral veins. In these latter, however, it can seldom be recognised as a separate entity, being merged in the general septic process from which it takes origin. Its occurrence may be inferred, if in the course of a suppurative lesion there is a sudden rise of temperature, with pain, redness, and swelling along the line of a venous trunk, and a rapidly developed œdema of the limb, with pitting of the skin on pressure. In rare cases a localised abscess forms in the vein and points towards the surface.

The clinical features of thrombo-phlebitis of the lateral sinus are described elsewhere.

Treatment.—In the case of the peripheral veins the diagnosis can seldom be made with sufficient certainty to permit of local treatment of the inflamed and suppurating vein. Attention must therefore be directed towards the septic condition with which the phlebitis is associated. In some cases—for example, in septic compound fractures—the occurrence of suppurative phlebitis may necessitate amputation of the limb. Ligature of the vein on the cardiac side of the thrombus with a view to preventing embolism is seldom feasible in the peripheral veins, although, as will be pointed out later, the jugular vein may be ligatured with this object in cases of thrombosis of the lateral sinus.

Varix—Varicose Veins.

The term varix is applied to veins which are so altered in their structure that they remain permanently dilated, and are at the same time lengthened and tortuous.

Any vein in the body may become varicose, but the condition is extremely rare except in the veins of the lower extremity, in the veins of the spermatic cord (varicocele), and in the veins at the lower end of the rectum (hæmorrhoids).

Varicocele and hæmorrhoids will be described elsewhere. We are here only concerned with varix as it occurs in the veins of the lower extremity.

Etiology.—Considerable difference of opinion still exists as to the essential cause of varix, but the weight of evidence is in favour of the view that it results from a congenital defect in the structure of the affected vessels, and that it is allied to certain of the angiomata.

This view was held by Virchow, who applied to the condition the term *angioma racemosum venosum.* It is supported by the fact that in a large proportion of cases the condition is hereditary. Not only may several members of the same family in succeeding generations suffer from varix, but it is often found that the same vein, or segment of a vein, is involved in all of them. The frequent occurrence of the disease in youth is also a strong indication of its hereditary nature.

Little that is certain is known regarding the nature of this defect, but it is probable that it lies in a deficiency in the number, size, and strength of the valves of the affected veins, and in an inherent weakness of the vessel walls.

This congenital predisposition may exist without the patient manifesting any of the clinical phenomena associated with varix, and in the majority of cases it is only when some exciting factor comes into operation that these appear.

The most common exciting cause of varicosity is increased pressure within the veins, and this may be produced in a variety of ways. In different diseases of the heart, lungs, and liver, for example, the venous pressure may be so raised as to cause a localised dilatation of such veins as are congenitally weak. The direct pressure of a tumour, or of the gravid uterus, on the large venous trunks in the pelvis, may so obstruct the flow as to distend the veins of the lower extremity. It is a common experience that in women the signs of varix date from an antecedent pregnancy. There is abundant evidence that the importance of the wearing of tight garters as a factor in the production of varicose veins has been much exaggerated, although it must be admitted that this practice is calculated to aggravate the condition when it is once established. It has been proved experimentally that the backward pressure in the veins may be greatly increased by straining, a fact which helps to explain the frequency with which varicosity occurs in the lower limbs of athletes and of those whose occupation involves repeated and violent muscular efforts. There is reason to believe, moreover, that a sudden strain may, by rupturing the valves and so rendering them incompetent, induce varicosity independently of any congenital defect.

Prolonged standing or walking, by allowing gravity to act on the column of blood in the veins of the lower limbs, is also an important determining factor in the production of varix.

Thrombosis of the deep veins—in the leg, for example—may induce marked dilatation of the superficial veins, by throwing an increased amount of work upon them. This is to be looked upon rather as a compensatory hypertrophy of the superficial vessels than as a true varix.

Morbid Anatomy.—As has already been said, varix is chiefly met with in superficial veins, and more particularly in those of the lower extremity—the internal and external saphenous veins. With the exception of the venæ comites of the posterior tibial and peroneal arteries, the deep veins appear to escape.

The whole length of the vein may be affected, but as a rule the disease is confined to one or more segments of it. These segments are not only dilated, but in many cases are also increased in length, so that they become more or less convoluted. The adjacent loops of the convoluted vein are often bound together by fibrous adhesions. All the coats are thickened, chiefly by an increased development of fibrous tissue, and in some cases changes very similar to those of atheroma occur. The walls of varicose veins are often exceedingly brittle. In some cases the thickening is uniform, and in others it is irregular, so that here and there thin-walled sacs or pouches project from the side of the vein (Fig. 45). These pouches vary in size from a bean to a hen's egg, the larger forms being called *venous cysts*, and being most commonly met with in the region of the saphenous opening and of the opening in the popliteal fascia. Such pouches, being exposed to injury, are frequently the seat of thrombosis.

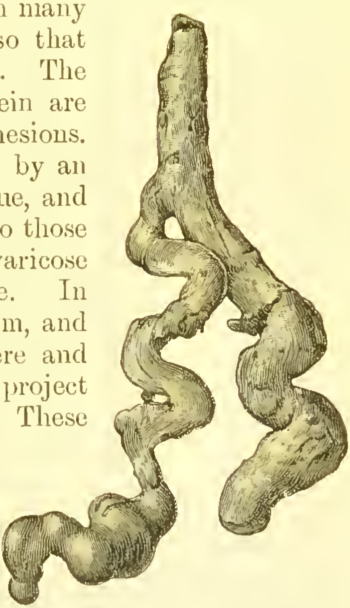

Fig. 45.—Portion of Varicose Vein excised, showing Tortuosity and Unequal Dilatation.

The essential anatomical lesion is the absence or deficiency of the valves, so that they are incompetent and fail to support the column of blood which bears back upon them. Normally the valves in the femoral and iliac veins and in the inferior vena cava are slightly, if at all, developed, so that in the erect posture the internal saphena receives a large share of the backward pressure of the column of venous blood. The valves may be incompetent although the vein is not dilated.

Clinical Features.—Children seldom suffer from varicose veins. The majority of cases are seen in patients between puberty and the age of thirty. The sexes appear to suffer about equally.

The amount of discomfort caused by varicose veins bears no direct proportion to the degree of varicosity. It depends rather upon the degree of pressure in the veins, as is shown by the fact that it is relieved by elevation of the limb. When the main trunk of the internal saphena is implicated, its valves being incompetent the pressure in the vein is high and the patient suffers a good deal of pain and discomfort. When, on the contrary, the upper part of the saphena and its valves are intact, and only the more distal veins are involved, the pressure is low and the symptoms are less severe, or may even be absent.

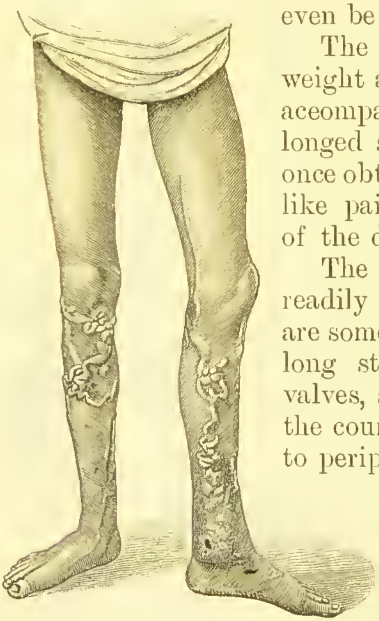
FIG. 46.—Extensive Varix of both Legs, with small Varicose Ulcer over Left Internal Malleolus.

The usual complaint is of a sense of weight and fulness in the limb, sometimes accompanied by actual pain after prolonged standing or walking. Relief is at once obtained by raising the limb. Cramp-like pains are often associated with varix of the deep veins.

The dilated and tortuous vein can be readily seen and felt. Bead-like swellings are sometimes to be detected in cases of long standing over the position of the valves, and on running the fingers along the course of the vessel a firm ridge, due to periphlebitis, may often be detected on each side of the vein. When the limb is œdematous, the outline of the veins is often obscured, but they can be identified on palpation as gutter-like tracks. When large veins are implicated, a distinct impulse on coughing may sometimes be seen to pass down as far as the knee; and if the vessel be sharply percussed a fluid wave may be detected passing both up and down the vein.

If the patient be placed on a couch and the limb elevated the veins are emptied, and if pressure be then made over the region of the saphenous opening and the patient allowed to stand up, they do not fill again until the pressure is removed, and then the blood rapidly rushes in from above.

The most marked dilatation usually occurs on the inner side of the limb, between the middle of the thigh and the middle of the calf, the arrangement of the veins showing great variety.

There are usually one or more bunches of enlarged and tortuous veins in the region of the knee, and sometimes at the ankle. Frequently a large branch establishes a communication between the systems of the internal and external saphenous veins in the region of the popliteal space, or across the front of the upper part of the tibia. The superficial position of this last branch and its proximity to the bone render it very liable to injury.

The small veins of the skin often show as fine blue streaks arranged in a stellate or arborescent manner. This is most often observed in women who have borne children.

Complications.—Chronic eczema and ulcers are often met with in the lower part of the leg in association with varix, and are due to interference with the nutrition of the skin. The incompetence of the valves allows the pressure in the varicose veins to equal that in the arterioles, so that the capillary circulation is impeded. From the same cause the blood in the deep veins is enabled to enter the superficial veins, where the backward pressure is so great that the blood flows down again, and so a vicious circle is established. The blood therefore loses more and more of its oxygen, and so fails to nourish the tissues.

When the varicosity is of long standing, the skin may become pigmented, assuming a mahogany-brown or bluish hue.

Profuse hæmorrhage may take place from a varicose vein as a result of a wound or of ulceration of its walls. The increased intra-venous pressure produced by severe muscular strain may determine rupture of a vein exposed in an ulcer. If the limb be dependent, the incompetency of the valves permits of very rapid and copious bleeding, which may prove fatal, particularly if the patient be intoxicated when the rupture takes place. The bleeding may, however, at once be arrested by elevating the limb, or by applying pressure directly over the bleeding point.

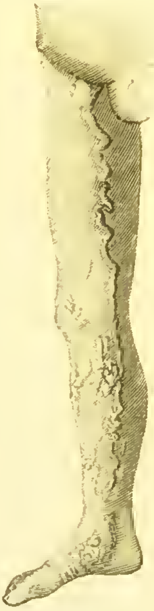
FIG. 47.—Varix of Internal Saphena Vein, with Saccular Dilatation over Saphenous Opening.

Phlebitis and thrombosis are common sequelæ of varix, and may prove dangerous, either by spreading into the large venous trunks or by giving rise to emboli. The larger the varix the greater is the tendency for a thrombus to spread upwards and to involve the deeper veins. Thrombi usually originate in venous cysts or pouches, and at acute bends on the vessel, especially when these are situated in the vicinity of the knee, and are subjected to repeated injuries—for example, in riding. In a certain proportion of cases, especially in elderly people, the occurrence of thrombosis leads to cure of the condition by the thrombus becoming organised and obliterating a portion of the length of the vein. Phleboliths sometimes form in such thrombi.

Treatment.—At best the treatment of varicose veins is only palliative, as it is obviously impossible to restore to the vessels their normal structure. The indications in treatment are to favour the venous return, and to prevent the condition becoming aggravated.

In early and mild cases these indications may be met by non-operative measures. The patient must avoid wearing anything, such as garters, which constricts the limb, and any obvious cause of direct pressure on the pelvic veins, such as a tumour, persistent constipation, or an ill-fitting truss, should be removed. Cardiac, renal, or pulmonary causes of venous congestion must also be treated, and the functions of the liver regulated. Severe forms of muscular exertion and prolonged standing or walking are to be avoided, and the patient may with benefit rest the limb in an elevated position for a few hours each day. To support the distended vessels a closely woven silk or worsted stocking, or a light and porous form of elastic bandage, applied as a puttee, should be worn. These appliances should be put on before the patient leaves his bed in the morning, and should only be removed after he lies down again at night. In this way the vessels are never allowed to become dilated. Elastic stockings, and bandages made entirely of indiarubber, are to be avoided.

In aggravated cases, where the patient is suffering pain, where bleeding or ulceration has occurred or is threatening, operative treatment is called for.

Operation is also indicated when the occupation of the patient is interfered with by repeated attacks of phlebitis, and when there are large pouches on the veins. The younger the patient the clearer is the indication to operate. Even when the condition causes the patient no trouble at all, it may be necessary to operate to enable him to enter any of the public services.

The operation of Trendelenburg is that most suitable when the trunk of the internal saphena vein is alone involved. It consists in exposing three or four inches of the vein in its upper part, applying a ligature at the upper and lower ends of the exposed portion, and after carefully tying all tributary branches, resecting this portion of the vein. It is important to include in the resection any large tributary near to the portion to be excised, to prevent it dilating and perpetuating the condition. When the varix is widespread, and especially if several trunks are implicated, it is better to remove several portions of the vein, each about three or four inches long, at intervals along its course. The patient should be confined to bed for not less than three weeks after the operation.

The treatment of the complications of varix has already been considered.

ANGIOMATA.[1]

Tumours of blood-vessels may be divided, according to the nature of the vessels of which they are composed, into the capillary, the venous, and the arterial angiomata.

CAPILLARY ANGIOMA.

The most common form of capillary angioma is the nævus or congenital telangiectasis.

Nævus.—A nævus is a collection of dilated capillaries, the afferent arterioles and the efferent venules of which often share in the dilatation. For practical purposes the most useful classification of nævi is into the cutaneous, the subcutaneous, and the mixed forms.

As is the case with other tumours, little is known regarding the *etiology* of nævi beyond the fact that they are markedly hereditary. Trauma probably plays no part in their causation, and their alleged association with maternal impressions is more than doubtful. Although usually described as congenital, these tumours are seldom noticed until the child is some days old. It is rare for the appearance of a nævus to be delayed beyond the fourteenth day.

The cutaneous nævus, "mother's mark," or "port-wine stain," consists of an abnormal aggregation of dilated capillaries in the substance of the skin. On stretching the skin the vessels may be seen to form a fine network, or to run in leashes parallel to one another. A dilated arteriole or a vein winding about among the capillaries may sometimes be detected. These nævi may occur on any part of the body, but they are most frequently met with on the face. They may be multiple, but are seldom if ever bilaterally symmetrical. They vary greatly in size, some being no bigger than a pin-head, while others cover nearly half the surface of the body. In colour they may present every tint from purple to brilliant red; in the majority there is a considerable dash of blue, especially in cold weather. As a rule the discoloration does not disappear when pressure is made over the tumour. The margin of the discoloured area is usually well defined, but does not project beyond the level of the surrounding skin, except when associated with the presence of a mole.

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[1] In the description of angiomata we have followed the teaching of the late John Duncan.

Unlike the other forms of nævi, the cutaneous variety shows little tendency to disappear, and usually remains persistent throughout life, especially when associated with moles and other hypertrophies of the skin.

As the nævoid tissue cannot be removed without producing a scar, which in most cases is even more disfiguring than the nævus, *treatment* is very unsatisfactory, and is of no avail except in very small and very superficial nævi. The best results have been obtained by long-continued use of counter-irritants—liniment of iodine being the most manageable—but the effects are far from certain.

The purely *subcutaneous* nævus is very rare. It presents, on section, the appearance of a finely reticulated sponge with imperfectly marked lobulation. The walls of the spaces are thin, and are lined by endothelium continuous with that of the blood-vessels. The reticulation is probably produced by the adhesion of adjacent portions of dilated capillaries and the subsequent atrophy of their walls, so that they come to communicate. The tumour may possess a distinct capsule, especially when it has ceased to grow or is retrogressing. The presence of one or more large arterioles in these nævi sometimes causes them to pulsate (arterial nævus). In other cases the venous element predominates, and the condition is then allied to varix.

Although it may be present at or within a few days of birth, a subcutaneous nævus is often overlooked, especially when on a covered part of the body, and may not be discovered till the patient is some years old. It forms a rounded, nodulated swelling under the skin, which is seldom of large size, and may be diminished by pressing the blood out of it, but it slowly fills again when the pressure is relaxed. It may swell up when the child struggles or cries. The skin over the swelling is normal in appearance, but may exhibit a bluish tinge, especially in cold weather.

A subcutaneous nævus has to be diagnosed from other subcutaneous swellings, such as fatty, cystic, and sarcomatous tumours, cold abscess, and hernia.

When it occurs in the middle line of the face, head, or back, it may be mistaken for meningocele or spina bifida, from which it only differs in being less closely related to the bone—a point of difference not always easy to detect.

Mixed Nævus.—As its name indicates, the mixed nævus combines the characters of the other two varieties. It differs from the subcutaneous variety only in the fact that the superficial portion of the tumour invades the skin.

It is frequently met with on the face and head, but may occur on any part of the body. It sometimes affects parts covered by mucous membrane, such as the cheek, tongue, and soft palate. The swelling is rounded or lobulated, and projects beyond the level of its surroundings. Sometimes the skin is invaded by the nævoid tissue over the whole extent of the tumour, sometimes only over a limited area (Fig. 49). Frequently the margin only is of a bright-red colour, while the skin over the centre of the swelling resembles a cicatrix. The swelling can be reduced by steady pressure. It increases in size and becomes more tense when the child cries.

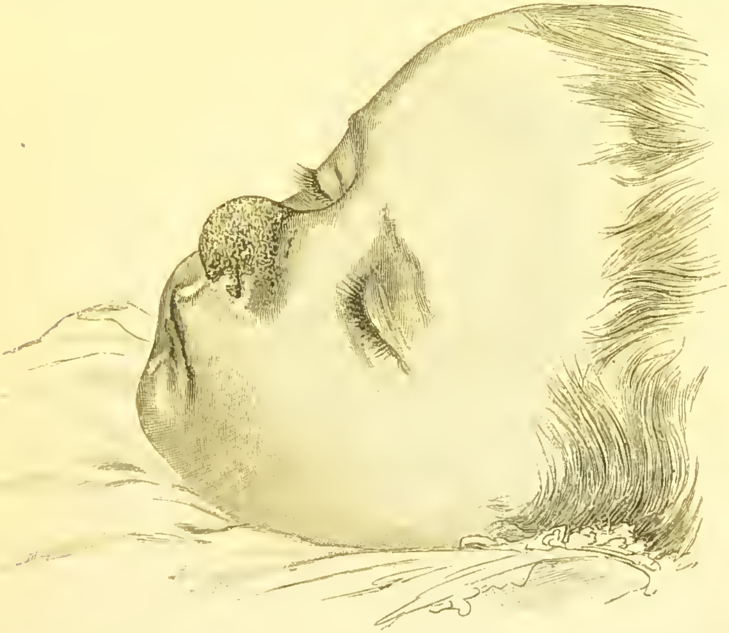

FIG. 48.—Mixed Nævus of Nose cured by Electrolysis.

Prognosis.—The rate of growth of the subcutaneous and mixed forms of nævi varies greatly. They sometimes increase very rapidly, especially during the first few months of life. After this, however, they usually grow at the same rate as the child, or even more slowly. There is a decided tendency to spontaneous disappearance of these varieties, fully 50 per cent undergoing natural cure. This usually begins about the period of the first dentition, sometimes at the second dentition, and sometimes about puberty. On the other hand, an increased activity of growth may be shown at these periods. The onset of natural cure is recognised by the tumour becoming firmer and less compressible, and in the mixed variety, by the colour becoming less bright. Injury, inflammation or ulceration of the overlying skin often initiates the curative process.

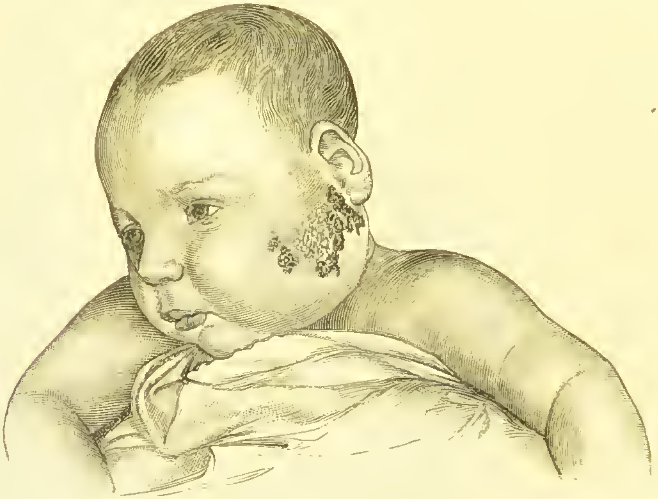

FIG. 49.—Large Mixed Nævus of Cheek in child æt. 1½ ; the Skin is only slightly involved. Cured by Electrolysis.

Subcutaneous nævi may in later life develop arterial connections, leading to the formation of one of the forms of cavernous angioma.

Treatment.—Bearing in mind the frequency with which subcutaneous and mixed nævi disappear spontaneously, active treatment is only called for when the growth of the tumour is out of proportion to that of the child, or when from its situation —for example, in the vicinity of the eye—it is liable to do harm in its growth.

Of the numerous methods of treatment which have been devised, it is only necessary to refer to the application of escharotics, electrolysis, and excision.

The application of *escharotics* has but a limited field of usefulness. They may be employed with benefit in very small nævi occurring on the face. A pointed piece of wood is dipped in strong nitric acid, and then thrust into the centre of the nævoid spot.

For large nævi the choice lies between electrolysis and excision—the former method being selected when the nævus is on an exposed part of the body, where it is desirable to avoid a scar; the latter when it is on a part covered by the clothes.

Electrolysis acts by decomposing the blood and tissues into their constituent elements—oxygen and acids appearing at the positive, hydrogen and bases at the negative electrode. These substances and gases being given off in a nascent condition, at once enter into new combinations with anything in the vicinity with which they have a chemical affinity. In the nævus the practical result of this reaction is that at the positive pole nitric acid, and at the negative pole caustic potash, both in a state of minute subdivision, make their appearance. The effect on the tissues around the positive pole, therefore, is equivalent to that of an acid cauterisation, and on those round the negative pole to an alkaline cauterisation.

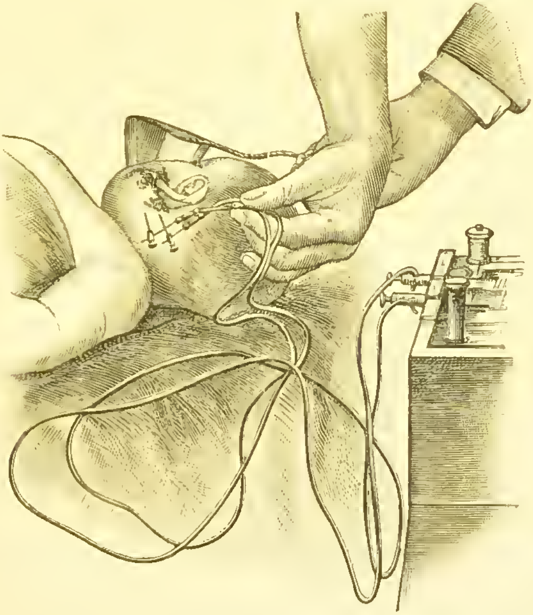

FIG. 50.—Electrolysis of Nævus under Chloroform Anæsthesia.

As the process is painful, a general anæsthetic is necessary. The current used should be from 20 to 80 milliampères, gradually increasing from zero, without shock; three to six large Bunsen cells give a sufficient current. Steel needles insulated with vulcanite to within an eighth of an inch of their points are the best. Both poles are introduced into the nævus, the positive being kept fixed at one spot, while the negative is moved about inside the tumour, so as to produce a number of different tracks of cauterisation. On no account must either pole be allowed to come in contact with the skin lest a slough be formed. The duration of the sitting is determined by the effect produced. The object aimed at is to produce hardening of the tumour. If pallor of the skin appears, it indicates that the needles are too near the surface, or that the blood-supply to the integument is being cut off, and is an indication to stop. The average duration is from fifteen to twenty minutes. To cauterise the track and so prevent bleeding, the needles should be slowly withdrawn while the current is flowing. When the skin is reached the current is turned off. The punctures are covered with collodion. Six or eight weeks should be allowed to elapse before repeating the procedure. From two to eight or ten sittings may be necessary, according to the size and character of the nævus.

Excision is the best operation for nævi of moderate size situated on covered parts of the body, where a scar is of no importance. When only a small proportion of the nævus is cutaneous, the invaded piece of skin may be removed with the tumour.

Excision is preferable to ligature, as nothing is left to slough off and primary union can be relied upon. Its advantage over electrolysis is that a single operation is sufficient. There is practically no risk from hæmorrhage.

Cavernous Angioma.—The cavernous tumour proper consists solely of dilated capillaries, which communicate freely with one another and with large blood spaces formed by the disappearance of adjacent capillary walls. This variety is met with in internal organs as well as in the subcutaneous tissue. It may appear at any age from early youth to middle life, and is of very slow growth. The swelling is rounded or oval, and feels not unlike a fatty tumour. There is no pulsation or bruit, and the tumour is but slightly compressible. These tumours are best treated by excision, but when of large size and diffuse they may be electrolysed.

Aneurysm by Anastomosis is the name applied to a vascular tumour in which arteries, veins, and capillaries are all involved. It is chiefly met with on the upper part of the trunk, the neck, and the scalp. It tends gradually to increase in size, and may, after many years, attain an enormous size. The tumour is nodulated, ill-defined, and varies in consistence. It is pulsatile, and a systolic bruit or a "thrilling" murmur may be heard over it. The chief risk is hæmorrhage from injury or ulceration.

The *treatment* is conducted on the same lines as for nævus. Where electrolysis is employed, it should be directed towards the afferent vessels; and if it fails to arrest the flow through these, it is useless to persist with it. Excision is seldom justifiable on account of the risk from hæmorrhage. In some cases ligature of the afferent vessels has been successful.

Venous Angioma.—This term is sometimes applied to that form in which the venous element seems to predominate. There is no tumour composed entirely of veins, except certain varieties of varix, which have been described elsewhere.

Arterial Angioma.—*Cirsoid Aneurysm.*—This form of tumour is composed entirely of the enlarged branches of an arterial trunk. The condition originates in the smaller branches of an artery—usually the temporal—and may spread to the main trunk, and may even involve branches of other trunks with which the original artery normally anastomoses. This is not to be confused with the condition known as aneurysm by anastomosis which has already been described.

The condition is probably congenital in origin, though its appearance is frequently preceded by an injury.

The affected vessels increase in size, and become characteristically tortuous, with narrowings and dilatations here and there. Grooves or gutters are frequently found in the bone underlying the dilated vessels. Cirsoid aneurysm almost invariably occurs on the head. It is usually met with in adolescents or young adults, and it increases in size exceedingly slowly. There is no tendency either to natural cure or to rupture. Severe and even fatal hæmorrhage may follow a wound of the dilated vessels.

There is a constant loud bruit in the tumour, which greatly troubles the patient and may interfere with sleep.

The condition may be treated by excision or by electrolysis. In excision the hæmorrhage is controlled by an elastic tourniquet applied horizontally round the head, or by ligature of the feeding trunks. In large tumours the bleeding may be formidable. In many cases electrolysis is to be preferred, and is performed in the same way as for nævus. The positive pole is placed in the centre of the tumour, while the negative is introduced into the main affluents one after another.

ANEURYSM.

An aneurysm is a sac communicating with an artery, and containing fluid or coagulated blood.

Two types of aneurysm are met with—the pathological or spontaneous aneurysm, and the traumatic aneurysm. It is convenient to describe in this section also certain conditions in which there is an abnormal communication between an artery and a vein—arterio-venous aneurysm.

Pathological Aneurysm.

In this class are included such aneurysms as are produced by gradual dilatation of an artery, resulting from weakening of its coats, combined, in most cases, with a loss of elasticity in the walls and a marked increase in the arterial tension. The terms "spontaneous" and "idiopathic," commonly applied to aneurysms of this class, are singularly inappropriate in view of the distinct pathological agencies at work in their production.

In the majority of cases of pathological aneurysm the weakening of the artery and the diminution of the normal elasticity of its wall are due to atheroma. The recoil of the affected part of the vessel during diastole of the heart is diminished, and the increased vascular tension leads to gradual dilatation of the affected segment of the artery.

In other cases the vessel wall is softened by arteritis—especially the embolic form—so that it yields before the pressure of the blood.

Repeated and sudden raising of the arterial tension, as a result, for example, of violent muscular efforts or of frequent excessive indulgence in alcohol, plays an important part in the causation of aneurysm. These factors probably explain the comparative frequency of aneurysm in those who follow such arduous occupations as soldiers, sailors, dock-labourers, and navvies. In these classes the condition usually manifests itself between the ages of thirty and fifty—that is, when the vessels are beginning to degenerate, although the heart is still vigorous and the individuals are hard at work. The comparative immunity of women may also be explained by the less severe muscular strain involved by their occupations and recreations. Any cause which persistently increases the vascular tension also favours aneurysm formation—for example, plethora, chronic alcoholism, gout, or chronic Bright's disease.

Syphilis plays an important part in the production of aneurysm, but the precise way in which it acts is doubtful. It may be that it predisposes the patient to atheroma and induces a persistent increase in the vascular tension by the loss of elasticity of the vessel wall and narrowing of the lumen as a result of syphilitic arteritis. It is a striking fact that aneurysm is seldom met with in females who have not suffered from syphilis.

Varieties.—Different varieties of pathological aneurysm occur, according as the weakening of the arterial wall is general over a considerable segment of the artery, or is localised in one or more limited areas.

Fusiform Aneurysm.—When the whole circumference of a portion of an artery has been weakened, the tension of the blood causes the walls to dilate uniformly, so that a fusiform or tubular aneurysm results. All the coats of the vessel are stretched and form the sac of the aneurysm, and the affected portion is not only dilated but is also increased in length. This form is chiefly met with in the arch of the aorta, but may occur in any of the main arterial trunks. As the sac of the aneurysm includes all three coats, and as the inner and outer coats are usually thickened by the deposit in them of fibrous tissue, a fusiform aneurysm increases in size very slowly and seldom gives rise to urgent symptoms.

When the intima is roughened by atheroma, especially in the form of calcareous plates, shreds of clot may adhere to it, but as a rule a fusiform aneurysm contains only fluid blood.

It is not uncommon, especially in the aorta, for a localised dilatation of a specially weak portion of the sac to take place, a sacculated aneurysm being thus grafted on a fusiform aneurysm. This adds greatly to the gravity of the condition, as the sacculated portion is very liable to rupture.

Natural cure is occasionally effected by the emerging artery becoming occluded by a clot.

Sacculated Aneurysm.—When a limited area of the vessel wall is weakened—for example, by atheroma or by other form of arteritis—this portion yields before the pressure of the blood, and a sacculated aneurysm results. The intima and media being already damaged, or, it may be, destroyed, by the primary disease, the stress falls on the adventitia, which in the majority of cases, except in the earliest stages, constitutes the only element in the sac. To withstand the pressure the outer coat becomes thickened, and as the aneurysm increases in size it forms adhesions to surrounding tissues, so that fasciæ, tendons, nerves, and other structures may be found matted together in the wall of the aneurysm. The wall is further strengthened by the deposit on its inner aspect of blood-clot, which may eventually become organised.

The contents of the aneurysmal sac consist of fluid blood, and a varying amount of blood-clot which is deposited in concentric layers on the inner aspect of the sac, constituting a laminated clot. Towards the centre of the sac the clot is soft, red, and granular; while near the wall it is firm, and pale in colour, being more or less completely organised (Fig. 51).

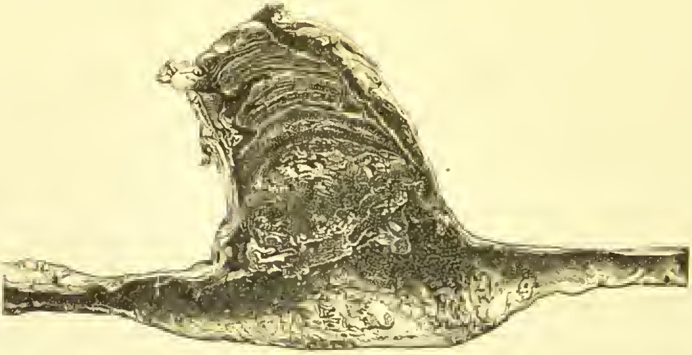

FIG. 51.—Sacculated Aneurysm of Abdominal Aorta nearly filled with laminated clot. Note greater density of clot towards periphery.

The laminated clot not only strengthens the sac, enabling it to resist the blood pressure, and so preventing rupture, but, if it increases sufficiently to fill the cavity, may bring about spontaneous cure. The principle upon which all methods of treatment are based is to imitate nature in producing such a clot.

So long as the sac remains intact the aneurysm is spoken of as *circumscribed;* when it gives way, and the blood escapes into the surrounding tissues, the aneurysm is said to be *diffused.*

When one or more of the coats of the artery enter into the formation of the sac, the aneurysm is sometimes called a "true aneurysm"; while the term "false" is applied when all the coats have given way and the sac is formed entirely by condensation of the surrounding structures. These terms, however, have been used in so many different senses, and are in themselves so misleading, that we do not employ them.

Dissecting Aneurysm.—The blood may force its way between the coats of the vessel—sometimes between the intima and media, but usually into the substance of the media—and so form a cul-de-sac in the substance of the vessel wall. This is spoken of as a dissecting aneurysm. It is more common in women than in men, and occurs in very feeble subjects. It usually originates in the aorta, and may spread widely—upwards into the carotids or downwards as far as the iliacs. Sometimes the blood finds its way into the lumen of the vessel again by bursting through a weakened spot, or it may burrow right through the middle and outer coats, causing the aneurysm to become diffused.

Clinical Features of Aneurysm.—Surgically the sacculated is by far the most important variety of aneurysm. The *fusiform* variety occurs chiefly in arteries which are inaccessible alike for diagnosis and treatment. When it occurs in more superficial arteries it is recognised by the shape and position of the pulsatile swelling. Its progress is usually so slow, it gives rise to so few symptoms, and is attended with so little risk, that even if diagnosed no active interference is as a rule called for. The treatment is entirely constitutional. The *dissecting* aneurysm also is seldom diagnosed during life, and no special treatment is available.

We shall, therefore, confine our attention here to the *sacculated* variety.

The outstanding clinical feature is the existence in the line of an artery of a more or less globular swelling, which pulsates, and with each pulsation expands. The expansion is detected by observing that when both hands are placed over the swelling they are separated with each beat of the heart. If the main artery be compressed on the cardiac side of the swelling, the pulsation is arrested and the tumour diminishes and becomes less tense. It may be still further reduced in size by making gentle pressure over it so as to empty it of fluid blood. On allowing the blood again to flow through the artery, after one or two beats of the heart the tumour fills up and the expansile pulsation returns. In most cases a distinct thrill is felt on placing the hand over the swelling, and a blowing, systolic murmur may be heard with the stethoscope. It is to be borne in mind that occasionally, when the interchange of blood between an aneurysm and the artery from which it arises is small, pulsation and bruit may be very slight or even absent. This is also the case when the sac contains a considerable quantity of clot. When it becomes filled with clot (*consolidated aneurysm*) these signs completely disappear, and the clinical features are those of a solid tumour lying in contact with an artery. *The effect of the aneurysm on the pulse* beyond is very characteristic. On the affected side the pulse in the artery beyond the aneurysm is smaller in volume and delayed by comparison with that in the normal artery on the healthy side. This is explained by the fact that the amplitude of the pulse wave varies directly, while its velocity varies inversely, with the diameter of the vessel through which the wave flows. The vessel beyond an aneurysm being contracted on account of the diminished amount of blood flowing through it,—a large quantity being retained in the sac,—the pulse wave is smaller in volume and is later in reaching a given point. A pulse tracing shows that the normal impulse and dicrotic waves are lost, and that the force and rapidity of the tidal wave are diminished.

An aneurysm exerts considerable pressure on the surrounding parts, which are usually much thickened and adherent to it and to one another. Adjacent veins may be so compressed that congestion and œdema of the parts beyond are produced. Occasionally a vein is opened into and an arterio-venous aneurysm produced. Pain, disturbances of sensation, and muscular paralyses may result from pressure on nerves. Considerable portions of bone may undergo atrophy and be absorbed by the gradually increasing pressure. This is most typically seen in the sternum and vertebræ. Cartilage, on the other hand, yields before the pressure, so that the intervertebral discs or the costal cartilages may escape while the adjacent bones are destroyed. The skin over the aneurysm gradually becomes thinned and stretched, until finally a slough having formed, it gives way, and when the slough separates hæmorrhage takes place.

Pain is a variable symptom. It may be due to the extreme tension in and around the aneurysm, and to the pressure exerted on sensitive structures, in which case it is of a constant, dull, boring character. When due to direct pressure on nerve trunks it is sharp and lancinating.

Differential Diagnosis.—Aneurysm is to be diagnosed from other pulsatile swellings. In some cases the pulsation of a new growth is transmitted from a large artery which lies in its vicinity. In other cases the tumour actually pulsates in virtue of its extreme vascularity. In neither case, however, is the pulsation expansile as in aneurysm—a most important point in differential diagnosis. Solid tumours, enlarged lymphatic glands, inflammatory swellings and abscesses, may receive pulsation from an underlying artery. In many cases the swelling can by appropiate manipulation be moved from the artery—in which case the pulsation ceases. Compression of the artery on the cardiac side of the swelling, although it arrests the pulsation, does not produce any diminution in the size or tension of the swelling, and when the pressure is removed the pulsation is immediately restored.

Fluid tumours, such as cysts, abscesses, or enlarged bursæ, may simulate aneurysm very closely. An apparent expansion may accompany the pulsation, but careful examination usually enables this to be distinguished from the marked expansion of an aneurysm. Compression of the artery makes no difference in the size or tension of the swelling.

Vascular tumours, such as sarcomata and goitres, may yield an expansile pulsation, but they differ from an aneurysm in that they are not diminished in size by compression of the main artery, nor can they be emptied by pressure. A soft, whiffing bruit is sometimes to be detected in certain parts of these tumours.

The exaggerated pulsation sometimes observed in a normal artery—for example, the "pulsating aorta" so often seen in women who suffer from dyspeptic symptoms—is not likely to be mistaken for that of an aneurysm.

Prognosis.—An aneurysm may either undergo natural cure or it may prove fatal. In some cases, however, it may remain stationary for a long period.

Natural cure is brought about by the formation in the aneurysm of laminated clot, which gradually increases in amount till it fills the sac and obliterates the artery on which the aneurysm is situated. The organisation of this clot converts the aneurysm and the part of the vessel from which it originates into a solid mass of fibrous tissue. The clot which obliterates the artery may be an extension of that which fills the sac. On the other hand, it may be a portion of the clot separated and impacted as an embolus in the artery beyond, leading to thrombosis which first occludes the artery and then extends into the sac.

The progress of natural cure is indicated clinically by the aneurysm becoming smaller, firmer, less expansile, and less compressible. The murmur and thrill are also diminished, and the pressure effects of the aneurysm become less marked. When the cure is complete the pulsation is lost, and there remains a small firm swelling attached to the vessel (*consolidated aneurysm*). While these changes are taking place the collateral arteries become enlarged, and an anastomotic circulation is established.

An aneurysm may prove *fatal* by exerting pressure on important structures adjacent to it, by causing syncope, by rupture, or from the occurrence of suppuration. *Pressure* symptoms are usually most serious from aneurysms situated in the neck, thorax, or skull. Sudden fatal *syncope* is not infrequent in cases of aortic and other large aneurysms.

Rupture may take place through the skin, into the cellular tissue, or into a mucous or serous cavity. The first hæmorrhage is often comparatively slight and stops naturally, but it soon recurs, and is so profuse, especially when the blood escapes externally or into a large cavity, that it rapidly proves fatal. When the bleeding takes place into the cellular tissue the aneurysm is said to become *diffused*, and the extravasated blood may spread widely through the tissues, exerting great pressure, and sometimes causing gangrene of the parts beyond from arrest of their blood-supply.

The clinical features associated with rupture of an aneurysm are sudden and severe pain in the part, while the patient becomes pale, cold, and faint. If a comparatively small escape of blood takes place into the tissues, the sudden alteration in the size, shape, and tension of the aneurysm, together with a loss of pulsation, may be the only local signs. When the bleeding is profuse, however, the parts in the neighbourhood of the aneurysm become greatly swollen, livid, and cold, and the characteristic signs of aneurysm at the same time disappear completely. The limb beyond the aneurysm becomes congested, swollen, and œdematous, and the pulses as a rule are completely lost. The arrest of the blood-supply may result in gangrene. Sometimes the pressure of the extravasated blood causes the skin to give way and fatal hæmorrhage results.

Suppuration may occur in the vicinity of an aneurysm, either before or after rupture, as a result of infection with pyogenic bacteria. The signs of acute inflammation and suppuration are superadded to those peculiar to the aneurysm. The aneurysm may burst into the abscess, so that when the latter points the pus is mixed with broken-down blood-clot, and finally free hæmorrhage takes place. It has more than once happened that even the most eminent surgeons have incised such abscesses without having recognised their association with aneurysm, with the most tragic results.

Treatment.—The numerous surgical measures employed in the treatment of aneurysm are all designed to imitate the process of natural cure, which has already been described.

In treating a case of aneurysm the indications are: to promote the coagulability of the blood, and so to favour the formation of a clot in the sac; and to obtain a permanent occlusion of the portion of the artery from which the aneurysm springs, without at the same time seriously endangering the nutrition of the parts beyond. General constitutional treatment effects certain of these objects, while others are attained by local measures.

Constitutional Treatment.—All forms of local treatment must be supplemented by general measures which tend to reduce the arterial tension and to diminish the force of the heart's action. The patient must be kept in bed at absolute rest—muscular effort being as far as possible avoided. A low, dry, and non-stimulating diet is indicated, the quantity being gradually reduced till it is just sufficient to satisfy the patient and to maintain his nutrition. Saline purges or even venesection may be employed to reduce the vascular tension. The benefit derived from the administration of potassium iodide administered in full doses, as first recommended by George W. Balfour, probably depends on its depressing action on the heart. Pain or restlessness may call for the use of moderate doses of opium.

Local Treatment.—The constitutional treatment above described is only to be looked upon as accessory to local measures, such as excision of the sac, ligature of the artery, compression of the artery, or the induction of coagulation in the sac by the introduction of foreign bodies, by which alone the permanent occlusion of the artery and the obliteration of the sac can be effected.

Excision of the Aneurysm.—Where it is available this is the most radical and the most certain method of treatment. Originally practised by Antyllus (A.D. 300)—hence the name "old operation" by which it is sometimes known—this procedure was revived by Syme, and has been widely practised by Annandale and others.

In the neck and in other situations where a tourniquet cannot be employed, the sac must be incised, and a finger quickly passed into the lumen of the artery so as to plug it and prevent bleeding, while the clots are being turned out and the ligatures applied. The risk from hæmorrhage renders this one of the most formidable operations of surgery.

In the limbs the circulation is controlled by a tourniquet—preferably that of Petit which can be rapidly slackened and tightened—as may be necessary. The aneurysm is freely exposed, and, after the vessel has been ligatured above and below, the sac is opened and the clots turned out. The sac is then dissected away, any vessels coming off from it ligatured, and if the vein is adherent to it, as is frequently the case, a portion of that vessel may be removed with the sac. Experience proves that the removal of a limited portion of both artery and vein at the same time is seldom followed by gangrene, so long as infection is excluded.

This method of treatment is particularly suitable to all forms of sacculated aneurysm of the limbs, so long as they are tolerably circumscribed and free from complications. It has also been successfully practised in subclavian, carotid, and external iliac aneurysms. This operation is not appropriate to cases in which there is advanced atheroma of the artery above and below the sac.

When the aneurysm has become diffused it may be impossible to excise the sac completely. In such cases the vessel may be ligatured, either before or after opening the sac and clearing out the clots, and the empty sac left to contract and heal, which it usually does satisfactorily. When there is difficulty, on account of adhesions, in applying the ligature to the artery after opening and emptying the sac a bougie may be passed into the lumen of the vessel and the ligature thrown round it with the aid of an aneurysm needle, the bougie being withdrawn as the ligature is tightened (Annandale). This manœuvre may be repeated at the distal end.

Fusiform aneurysm, unless very limited and slowly progressing, is less suitable for treatment by excision.

Ligature of the Artery.—The principle of this operation is to arrest, or so far to diminish, the flow of blood through the aneurysmal part of the artery that coagulation takes place in the sac and the clot spreads to the artery and occludes it.

The ligature may be applied on the cardiac side of the aneurysm, either immediately above the sac (Anel's operation, 1710) or at some distance above (John Hunter, 1785).

On the other hand, one or more branches may be ligatured on the distal side of the aneurysm, so as totally to arrest the flow through the sac (Brasdor's operation, 1760)—for example, for aneurysm of the proximal end of the common carotid the vessel may be ligatured near its bifurcation. The distal operation may also be performed, merely to diminish the quantity of blood passing through the affected artery without completely stopping the stream (Wardrop's operation, 1825)—for example, for innominate aneurysm the common carotid and third part of the subclavian may be ligatured, the branches of the first part of the subclavian being left pervious.

Anel's operation—proximal ligature close to the sac—has been practically abandoned, as the cases to which it is suitable can be treated with greater safety and certainty by the old operation.

The advantages of Hunter's operation—one of the epoch-making operations of surgery—have been largely discounted by the employment of antiseptic methods of operating. Its chief claim is its simplicity, the ligature being applied to a healthy part of the artery whose relations are undisturbed by the proximity of the aneurysm—for example, ligature of the femoral in Scarpa's triangle or in Hunter's canal, for popliteal aneurysm.

The distance between the seat of ligature and the sac renders the establishment of a collateral circulation through intervening branches easy and rapid, and this, while it diminishes the risk of gangrene, permits the access of fresh blood to the aneurysm before there is time for an occluding clot to be formed or organised. The cure, therefore, is not certain; and even when a clot forms it may be only temporary, and may disappear, so that pulsation in the sac soon returns.

This "recurrent pulsation" after ligature of an artery may be due to imperfect occlusion of the vessel at the seat of ligature, to too early absorption of the catgut ligature allowing the vessel to become pervious again, to the rapid establishment of a free collateral circulation, or to the reabsorption of the clot which temporarily occluded the artery.

The *operation of ligature of an artery in its continuity* is performed through an incision which usually runs more or less in the long axis of the vessel. The part of the artery to which the ligature is to be applied is exposed by dissection, care being taken to avoid opening up the cellular planes in the tissues more than is absolutely necessary. The vessel is recognised by its pulsation, and a portion sufficiently cleared of its sheath to enable the aneurysm needle to be passed without force. The wall of the vessel should be disturbed as little as possible, to avoid damaging the vasa vasorum through which it is nourished. The needle—threaded or unthreaded according to circumstances—is passed round the vessel from the side on which the most important structures lie. Where there is a single large vein accompanying the artery the needle is passed from the side on which the vein lies. Where there are venæ comites the presence of a nerve trunk on one or other side will determine the direction in which the needle is passed. The ligature—silk or chromicised catgut—is tied in a reef knot or in a stay knot.

A stay knot consists of two ligatures applied side by side, each having the first turn of a reef knot tied separately. The two ends on each side are then used as a single cord with which to make the second turn of the reef knot (Ballance and Edmunds). The wound is sutured without drainage.

The *after treatment* consists in wrapping the limb in cotton wool to conserve its heat, and elevating it sufficiently to promote the venous return, without at the same time impeding the arterial flow — a similar line of treatment to that already described in connection with ruptured arteries.

Compression.—With a view to promoting coagulation in the sac the circulation may be temporarily arrested by compressing the artery on the cardiac side of the aneurysm. To be efficient the compression must be kept up continuously for several hours. It is best accomplished by digital pressure applied over a superficial part of the vessel where it overlies a bone. As the compressing hand soon gets tired, to ensure the pressure being continuously and efficiently maintained it is necessary to have a relay of competent assistants to relieve one another. The pressure should be sufficient to stop pulsation in the aneurysm, although it should not completely arrest the flow through the artery. Great care is necessary while the assistants are relieving one another, to avoid a rush of blood through the aneurysm. It is advisable to vary slightly the point of pressure, lest the skin and deeper parts be injured by the prolonged compression.

Digital compression is chiefly applicable to aneurysm of the superficial femoral and popliteal arteries.

Compression by instruments—tourniquets, weights, and other forms of compressor—is less satisfactory than that by the fingers. The appliances are difficult to regulate and to maintain in position, and, in addition to being painful, they are liable to cause irritation or even sloughing of the soft parts pressed upon.

The results of compression are very variable and uncertain. Sometimes coagulation takes place rapidly, and the clot formed permanently cures the aneurysm. In other cases a laminated clot is slowly formed, many weeks being required for the complete occlusion of the sac. Not infrequently, the clot which forms only temporarily arrests the pulsation, and subsequently disappears, so that the pulsation is restored. In some instances even prolonged pressure skilfully applied entirely fails to induce coagulation.

Flexion.—In small and slowly growing aneurysms at the bend of the elbow or in the popliteal space, the circulation may be arrested and coagulation induced by flexing the joint so that the sac is pressed against the artery, and the artery slightly kinked. The limb below the aneurysm is bandaged, and the flexed attitude is maintained for several hours.

Reid's Method by Elastic Bandage.—In aneurysms of the limbs the principle of compression may be applied after the method of Reid. An elastic bandage is firmly applied from the fingers or toes to just below the aneurysm. It is lightly applied as it passes over the swelling, and again tightened above. As the circulation through the limb is thus completely arrested, the bandage must not be left on for more than an hour, for fear of inducing gangrene. As the bandage is being removed the artery should be controlled by digital pressure to prevent a sudden inflow of blood disturbing the clot which may have formed. This pressure should be maintained for some hours.

In view of the uncertainty of the results, the discomfort to the patient, and the trouble involved in carrying out these various methods of compression, the application of a ligature—which is merely another way of carrying out the same principle—is usually preferable.

Other Methods of Treatment.—Various methods have been employed to induce coagulation by the introduction into the sac of foreign bodies. Of these the safest and most satisfactory are Macewen's acupuncture or "needling" method, electrolysis as advocated by John Duncan, and the Moore-Corradi method. These procedures are specially indicated in internal aneurysms, and in external aneurysms—such as gluteal, sciatic, or vertebral aneurysms—which are so situated that the methods already described are rendered impracticable.

Macewen's method consists in passing one or more fine, highly tempered steel needles into the aneurysm, with the object of scarifying the inner surface of the sac. The needles are made to touch the opposite wall of the sac, and the pulsation of the aneurysm imparts the necessary movement to them. The blood coagulates on the rough surface produced, and the clot thus formed increases in size till it may fill the sac of the aneurysm. As much of the inner aspect of the sac as can be reached should be scarified, to increase the area of clot formation and to render the clot uniformly thick. The needles may be left in position for some hours, the projecting ends being surrounded with sterile gauze.

Electrolysis is applied to an aneurysm in the same way as to a nævus. The results, however, are not so satisfactory, the clot formed showing a tendency to become reabsorbed after temporarily effecting an improvement. The results seem to be best when the needle is made to scratch the wall of the sac—a combination of "needling" and galvano-puncture.

The *Moore-Corradi method* consists in introducing through the wall of the aneurysm a hollow insulated needle, through the lumen of which from ten to twenty feet of highly drawn silver or other wire is passed into the sac, where it coils up into an open meshwork. The positive pole of a galvanic battery is attached to the wire, while the negative pole is placed over the patient's back. A current, varying in strength from twenty to seventy milliampères, is allowed to flow for about an hour. The hollow needle is then withdrawn, but the wire is left *in situ.* The results are somewhat similar to those obtained by needling and by electrolysis, but the clot formed on the large coil of wire is more extensive.

Subcutaneous Injections of Gelatin.—This method of treating inoperable cases of sacculated aneurysm is still on its trial. It is based on the fact that a solution of gelatin introduced into the circulation increases the coagulability of the blood. Three or four ounces of a two per cent. solution of white gelatin in sterilised water, at a temperature of about 100° F., are injected into the subcutaneous tissue of the abdomen every two, three, or four days. In the course of a fortnight or three weeks improvement begins. The clot which forms is liable to soften and be absorbed, but a repetition of injections has in several cases established a permanent cure.

In rare cases *amputation* is the only treatment which offers a prospect of saving life. It is chiefly indicated in cases complicated by suppuration, by secondary hæmorrhage after excision or ligature, or by gangrene.

Amputation beyond the aneurysm has been performed as a means of arresting the blood-flow through the sac, and so effecting a cure—for example, amputation at the shoulder for subclavian aneurysm (Fergusson).

TRAUMATIC ANEURYSM.

The essential difference between a pathological and a traumatic aneurysm is that the latter is produced by some form of injury which divides all the coats of the artery. The walls of the injured vessel are usually healthy, but they form no part of the sac of the aneurysm. The sac consists of the condensed and thickened soft tissues which surround the artery, together with a variable amount of laminated clot.

The injury to the artery may be of the nature of a subcutaneous wound or tear, such as is produced by the fragments of a broken bone, or it may be a punctured wound from a stab or cut. Only small wounds of arteries give rise to traumatic aneurysm, as extensive wounds are attended with a sudden and profuse hæmorrhage into the cellular tissue which shows no tendency to become limited. These have already been described under ruptured artery.

The aneurysm may form soon after the injury is inflicted, and before the wound in the wall cicatrises. Blood slowly escapes into the surrounding tissues, gradually displacing and condensing them, until they form a distinct sac enclosing the effused blood. Towards the periphery the blood coagulates, and, being under considerable pressure, the clot becomes condensed.

Less frequently a traumatic aneurysm forms some considerable time after the injury, from gradual stretching of the fibrous cicatrix by which the wound in the wall of the artery has been closed. The gradual stretching of this cicatrix results in condensation of the surrounding structures which form the sac, on the inner aspect of which laminated clot is deposited.

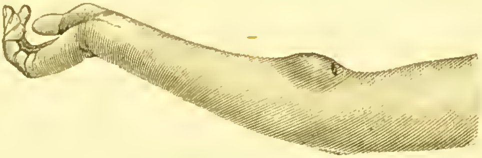

FIG. 52.—Traumatic Aneurysm of Brachial Artery, in girl æt. 16, caused by stab with pen-knife.

A traumatic aneurysm is almost always sacculated, and, so long as it remains circumscribed, has the same characters as a pathological sacculated aneurysm, with the addition that there may be external evidence of a wound. A traumatic aneurysm is very liable to rupture and become diffuse—a change which frequently brings about a cure.

The treatment of traumatic aneurysm is governed by the same principles as apply to the pathological varieties. The walls of the artery being healthy, operative measures dealing with the sac and its feeding arteries are safer than in pathological aneurysms.

ARTERIO-VENOUS ANEURYSM.

Any abnormal communication between an artery and a vein constitutes an arterio-venous aneurysm. Two varieties are recognised—one in which the communication is direct (*aneurysmal varix*); the other in which the vein communicates with the artery through the medium of an aneurysmal sac (*varicose aneurysm*).

Either variety may result from pathological causes, but in the vast majority of cases they are traumatic in origin, being due to such injuries as stabs, punctured wounds, and gunshot injuries which involve both artery and vein. In former times the most common situation was at the bend of the elbow, the brachial artery having been accidentally punctured in performing phlebotomy of the median basilic vein. Arterio-venous aneurysm is a frequent result of injuries by modern high-velocity bullets.

Both in aneurysmal varix and in varicose aneurysm the higher blood pressure in the artery forces arterial blood into the veins, which become distended and thickened, and in course of time assume certain of the characters of varicose veins.

In *aneurysmal varix* the vein near to the point of communication with the artery tends to become dilated, and to form a thick-walled sac, beyond which the vessel and its tributaries are distended and tortuous. The free flow of arterial blood through this varicose vessel makes it pulsate, and produces in it a marked vibratory thrill and a loud murmur. In addition to these characters, the clinical features of aneurysmal varix closely resemble those associated with varicose veins. The tendency of the varix is to remain stationary. Rupture is exceedingly rare.

As a rule, the support of an elastic bandage is all that is necessary in the way of treatment, but when the condition causes serious inconvenience the artery should be ligatured above and below the point of communication.

Varicose aneurysm usually develops in relation to a traumatic aneurysm, the vein involved having formed adhesions with the sac, and ultimately opened into it. In this way a communication between the artery and the vein is established.

Clinically the patient exhibits a combination of the features of traumatic aneurysm and aneurysmal varix.

As there is little tendency to spontaneous cure, and as the aneurysm is liable to increase in size and finally to rupture, operative treatment is usually called for. This consists in applying a ligature to the artery above and below the point of communication, and at the same time incising the sac, turning out the clots, and ligaturing any branches which happen to open into the sac. The vein should not be ligatured unless it is absolutely necessary.

ANEURYSMS OF INDIVIDUAL ARTERIES.

After what has been said of aneurysm in general, it is only necessary to refer very briefly to the more salient points bearing on aneurysms as they occur in individual arteries. To avoid repetition, it may be stated that in the treatment of all aneurysms local measures are supplemented by the employment of the general constitutional treatment already described. It may also be assumed that while the measures mentioned as suitable to each of the special aneurysms are to be preferred, circumstances may make it necessary to have recourse to one of the other procedures already mentioned. No hard-and-fast rules can be laid down for the treatment of a condition which varies so widely in different cases.

Thoracic Aneurysm.—The arch of the aorta is the most common seat of aneurysm, but surgical treatment is rarely called for.

All varieties of aneurysm occur in the aorta, the fusiform being the most common. Frequently a sacculated aneurysm springs from a fusiform dilatation. Dissecting aneurysm occurs with greater frequency in the aorta than in any other vessel.

The *clinical features* depend chiefly on the direction in which the aneurysm enlarges, and are not always well marked even when the swelling is of considerable size. They consist in a pulsatile swelling—sometimes in the episternal notch, but usually towards the right side of the sternum—with an increased area of dulness on percussion. Pain is usually a prominent symptom, and is largely referable to the pressure of the aneurysm on the vertebral column or the sternum, causing erosion of these bones. Pressure on the thoracic veins or on the air-passages may cause cyanosis and dyspnœa. When the œsophagus is pressed upon, dysphagia may result. The left recurrent laryngeal nerve may be stretched or pressed upon as it hooks round the arch of the aorta, and hoarseness of the voice and a characteristic "brassy" cough may result from paralysis of the muscles of the larynx which it supplies. The vagus, the phrenic, and the spinal nerves may also be pressed upon. When the aneurysm is on the transverse part of the arch the trachea is pulled down with each beat of the heart—a clinical phenomenon known as the "tracheal tug." Aneurysm of the descending thoracic aorta may, after having eroded the bodies of the vertebræ and posterior portions of the ribs, form a swelling in the back to the left of the vertebral column. In such cases great pain is caused by pressure on the spinal nerves.

The surgical methods of *treatment* for thoracic aneurysm are merely palliative, and are designed to avert rupture. Needling, electrolysis, the Moore-Corradi method, and the subcutaneous injection of gelatin have all been employed with this object. Christopher Heath recommends ligature of the left common carotid as a distal operation in aneurysm of the transverse part of the aortic arch.

Aneurysm of the Abdominal Aorta.—The most common seats of aneurysm of the abdominal aorta are close to its bifurcation, and at the origin of the cœliac axis. Any of the large branches of the aorta may be the seat of aneurysm.

Aneurysm of the main trunk manifests itself by forming a pulsating swelling, which is to be distinguished from the "pulsating aorta" met with in anæmic and dyspeptic women, and from solid tumours overlying the artery. There is great pain when the aneurysm causes erosion of the vertebræ.

Electrolysis and the Moore-Corradi method have been successfully employed, access to the sac having been obtained by opening the abdomen. Ligature of the aorta has so far been unsuccessful.

Innominate Aneurysm may be of the fusiform or of the sacculated variety, and is frequently associated with aneurysm of the aorta. It usually grows upwards and outwards, projecting above the sternum and right clavicle, which may be eroded or displaced by it. Symptoms of pressure on the structures in the neck, similar to those produced by aortic aneurysm, occur. The pulses in the right upper extremity and in the right carotid and its branches are diminished and delayed. Pressure on the right brachial plexus causes shooting pain down the arm and muscular paresis on that side. Vasomotor disturbances and contraction of the pupil on the right side may result from pressure on the sympathetic fibres. Death may take place from rupture, or from pressure on the air-passages.

The available methods of treatment are ligature of the right common carotid and third part of the right subclavian (Wardrop's operation). If this be impracticable, needling, electrolysis, or the Moore-Corradi method may be tried.

Carotid Aneurysms.—Aneurysm of the *common carotid* is more frequent on the right than on the left side, and is usually situated either at the root of the neck or near the bifurcation of the artery. It is the form of external aneurysm most frequently met with in women. From its position the swelling is liable to press on the vagus, recurrent laryngeal and sympathetic nerves, on the air-passages, and on the œsophagus, giving rise to symptoms referable to such pressure. There may be cerebral symptoms from interference with the vascular supply of the brain.

Aneurysm near the origin of the common carotid has to be diagnosed from subclavian, innominate, and aortic aneurysm, and from other swellings—solid or fluid—met with in the neck. It is often difficult to determine with precision the trunk from which an aneurysm at the root of the neck originates, and not infrequently more than one vessel shares in the dilatation. A careful consideration of the position in which the swelling first appeared, of the direction in which it has progressed, of its pressure effects, and of the condition of the pulses beyond, may help in distinguishing between aortic, innominate, carotid, and subclavian aneurysms. In some cases skiagraphy is of assistance in diagnosis.

Tumours of the thyroid, enlarged lymphatic glands, and fatty and sarcomatous tumours can usually be distinguished from aneurysm by the history of the swelling and by careful physical examination. Cystic tumours and abscesses in the neck are sometimes more difficult to differentiate on account of the apparently expansile character of the pulsation transmitted to them. The fact that compression of the vessel does not affect the size and tension of these fluid swellings is useful in distinguishing them.

Treatment.—Digital compression of the vessel against the transverse process of the sixth cervical vertebra—the "carotid tubercle"—has been successfully employed in the treatment of aneurysm near the bifurcation. Proximal ligature in the case of high aneurysms, or distal ligature in those situated at the root of the neck, is more certain. The old operation is probably the best method of treatment, especially in aneurysms of traumatic origin.

The *external carotid* and the cervical portion of the *internal carotid* are seldom the primary seat of aneurysm formation, although they are liable to be implicated by the upward spread of an aneurysm at the bifurcation of the common carotid. In addition to the ordinary signs of aneurysm, the clinical manifestations are chiefly referable to pressure on the pharynx and larynx, and on the hypoglossal nerve. When the hypoglossal nerve is implicated, the corresponding side of the tongue is paralysed. Aneurysm of the internal carotid is of special importance on account of the way in which it bulges into the pharynx in the region of the tonsil, in some cases closely simulating a tonsillar abscess. Cases are on record in which such an aneurysm has been mistaken for an abscess and incised, with disastrous results.

The most satisfactory method of treatment, when it is practicable, is by proximal ligature. On account of the free anastomosis between the branches of the arteries, digital compression of the common carotid is seldom successful in curing these aneurysms, and for the same reason ligature of the common carotid may also fail.

Aneurysmal varix may occur in the neck as a result of stabs, cuts, or gunshot wounds. The communication is usually between the common carotid and the internal jugular vein. The resulting interference with the cerebral circulation causes headache, giddiness, and other brain symptoms, and a persistent loud murmur is usually a source of great annoyance to the patient. If operative treatment is called for, the artery should be ligatured above and below the point of communication.

Intracranial aneurysm may involve the internal carotid and its branches, or the basilar artery. These aneurysms appear to be more frequently associated with syphilis and with valvular disease of the heart than are external aneurysms. They are seldom diagnosed from other intracranial tumours during life, as they give rise to no characteristic symptoms, save, in some cases, a loud murmur. They usually prove fatal by rupture and intra-cranial hæmorrhage. The only available treatment is ligature of the common carotid or of the vertebral artery in the neck.

Orbital Aneurysm.—The term pulsating exophthalmos is employed clinically to embrace a number of pathological conditions, including aneurysm, in which the chief symptoms are a marked pulsation in the orbit, and protrusion of the eyeball. There may be, in addition, congestion and œdema of the contents of the orbit and of the eyelids, and a distinct thrill and murmur, which can be controlled by compression of the common carotid in the neck. Varying degrees of ocular paralysis and of interference with vision may also be present.

These symptoms are due, in the majority of cases, to aneurysmal varix of the internal carotid artery and cavernous sinus, which is often traumatic in origin, being produced either by fracture of the base of the skull or by a punctured wound through the orbit. In other cases they are due to aneurysm of the ophthalmic artery, to thrombosis of the cavernous sinus, and, in rare instances, to cirsoid aneurysm of congenital origin.

If compression of the common carotid is found to arrest the pulsation, ligature of this vessel is indicated. Electrolysis has also been successful in the treatment of orbital aneurysm.

Subclavian Aneurysm.—Subclavian aneurysm is usually met with in men who follow occupations involving excessive use of the shoulder—for example, dock-porters and coal-heavers. It is more common on the right side.

The aneurysm usually springs from the third part of the artery, and appears as a tense, rounded, pulsatile swelling just above the clavicle and to the outer side of the sterno-mastoid muscle. It occasionally extends in the direction of the thorax, where it may become adherent to the pleura. The aneurysm is of slow growth, and has a considerable tendency to undergo spontaneous cure. The radial pulse on the same side as the aneurysm is small and delayed. Congestion and œdema of the limb, with pain, numbness, and muscular weakness, may result from pressure on the veins and nerves as they pass under the clavicle; and pressure on the phrenic nerve may induce hiccough.

The conditions most likely to be mistaken for subclavian aneurysm are a soft, rapidly growing sarcoma, and a normal artery raised on a cervical rib. It is to be borne in mind, however, that aneurysm is liable to develop in an artery so displaced by a cervical rib.

On account of the anatomical relations of the artery and the disposition of its branches, surgical treatment is less satisfactory in subclavian than in almost any other form of external aneurysm. Needling or electrolysis should be tried before resorting to operation. The available operative measures are proximal ligature—either of the innominate or of the first part of the artery itself, excision of the sac, and distal ligature. In some cases it has been found necessary to combine distal ligature with amputation at the shoulder-joint, to prevent the collateral circulation maintaining the flow through the aneurysm. All these operations are serious, and are only undertaken when less dangerous measures fail.

Axillary Aneurysm.—Any part of the axillary artery may be the seat of aneurysm. It is usually met with in the right arm of labouring men and sailors, and not infrequently follows an injury in the region of the shoulder. The vessel may be damaged by the head of a dislocated humerus or in attempts to reduce the dislocation, by the fragments of a fractured bone, or by a stab or cut. Sometimes the vein also is injured and an arterio-venous aneurysm established.

An axillary aneurysm grows more rapidly than a subclavian, and may soon attain a large size, filling up the axilla, and displacing the clavicle upwards. This renders compression of the third part of the subclavian difficult or impossible. It may extend beneath the clavicle into the neck, or, extending inwards, may form adhesions with the chest wall, and, after eroding the ribs, with the pleura.

The usual symptoms of aneurysm are present, and the pressure effects on the veins and nerves are similar to those produced by an aneurysm of the subclavian. Intra-thoracic complications—pleurisy, pneumonia, hæmoptysis—are not infrequent when the aneurysm forms adhesions to the chest wall and pleura. Rupture may take place externally, or into the pleura or the shoulder-joint.

Digital compression or ligature of the third part of the subclavian, needling, and electrolysis are the most generally applicable methods of treatment. In rare cases, where the sac is small, the old operation may be preferred.

Brachial aneurysm usually occurs at the bend of the elbow, is of traumatic origin, and is best treated by excision of the sac.

Aneurysmal varix, which was frequently met with in this situation in the days of the barber-surgeons,—usually as a result of the artery having been accidentally wounded while performing venesection of the median basilic vein,—may be treated, according to the amount of discomfort it causes, by a supporting bandage, or by ligature of the artery above and below the point of communication.

Aneurysms of the vessels of the **forearm and hand** call for no special mention. They are almost invariably traumatic, and are best treated by excision of the sac.

Inguinal Aneurysm (*Aneurysm of the Iliac and Common Femoral Arteries*).—Aneurysms appearing in the region of Poupart's ligament may have their origin in the external or common iliac arteries or in the common femoral. They tend to spread upwards towards the abdomen, and to a less extent downwards into the thigh, on account of the tension of the fascia lata. Sometimes a constriction occurs across the sac at the level of Poupart's ligament, giving the swelling a lobulated appearance.

The pressure exerted on the nerves and veins of the lower extremity causes pain, congestion, and œdema of the limb beyond. Rupture, either externally or into the cellular tissue of the iliac fossa, is a frequent mode of termination.

These aneurysms have to be diagnosed from abscess, rapidly growing soft sarcomata, especially of the pelvic bones, and enlarged lymphatic glands.

Electrolysis or needling may be considered, but the method of treatment which has met with most success has been ligature of the common or external iliac, reached either by reflecting the peritoneum from off the iliac fossa (extra-peritoneal operation), or by going through the peritoneal cavity (trans-peritoneal operation).

Gluteal and Sciatic Aneurysm.—It is only in their early stages that these aneurysms can be distinguished from one another. When they have increased so as to form a salient swelling in the buttock they closely resemble each other. The special symptoms to which they give rise are pain down the limb from pressure on the great sciatic nerve, and interference with the movements of the hip. The sciatic variety is specially liable to invade the cavity of the pelvis.

Ligature of the internal iliac by the trans-peritoneal method is the most satisfactory method of treatment. These aneurysms are also suitable for treatment by needling or electrolysis. The old operation is difficult and dangerous, especially when the aneurysm has spread into the pelvis.

Femoral Aneurysm.—Aneurysm of the femoral artery is usually traumatic in origin, and is more common in Scarpa's triangle than in Hunter's canal. Varicose aneurysm and aneurysmal varix are also met with in this situation. Any of the methods already described are available for their treatment —the operation of choice being ligature of the external iliac or the old operation.

Aneurysm of the *profunda femoris* is distinguished from aneurysm of the main trunk by the fact that the pulses beyond are, in the former, unaffected, and by the normal artery being felt pulsating over or alongside of the sac.

Popliteal Aneurysm.—Popliteal aneurysm is the most common surgical aneurysm met with in the body, and the condition is not uncommonly bilateral. It is generally due to disease in the artery, although repeated slight strains which are so liable to occur at the knee may play an important part in determining its formation. In former times it was very common in post-boys from the repeated flexion and extension of the knee in riding.

The aneurysm is usually of the sacculated variety, and may spring from the front or from the back of the vessel. According to the direction of its growth it exerts pressure on the bones and ligaments of the joint, and sometimes opens into the articulation.

The pain, stiffness, and effusion into the joint which accompany these changes often lead to an erroneous diagnosis. It may press upon the popliteal vein, causing congestion and œdema of the leg, which may end in gangrene. Pressure on the popliteal nerves gives rise to severe pain, muscular cramp, and weakness of the leg.

The differential diagnosis is to be made from aneurysm, abscess, bursal cyst, enlarged glands, and sarcoma.

The choice of operation lies between ligature of the femoral artery in Hunter's canal, and the old operation. The success which attends the Hunterian operation is evidenced by the fact that Syme performed it thirty-seven times without a single failure. Of recent years, however, the old operation has again come into favour, largely through the advocacy of Annandale and others. Experience shows that ligature of the vein, or even the removal of a portion of it, is not necessarily followed by gangrene if the wound remains aseptic. The onset of gangrene from any cause is an indication for immediate amputation.

Aneurysmal varix is sometimes met with in the region of the popliteal space. It is characterised by the usual symptoms, and is treated by palliative measures, or by ligature of the artery above and below the point of communication.

Aneurysm in the **leg and foot** is rare. It is almost always traumatic, and is best treated by excision of the sac.

CHAPTER XV.

THE LYMPHATICS.

Anatomy and physiology—INJURIES OF LYMPHATIC VESSELS: *Wounds of thoracic duct*—DISEASES OF LYMPHATIC VESSELS—Lymphangitis: *Varieties*—Lymphangiectasis—Filarial disease—Lymphangioma—DISEASES OF LYMPHATIC GLANDS—Lymphadenitis: *Septic; Tuberculous; Syphilitic*—Lymphadenoma—Leucocythæmia—TUMOURS.

LYMPH is essentially blood plasma which has filtered through the walls of capillaries. After bathing and nourishing the tissues, it is collected by lymphatic vessels, which return it to the blood-stream by way of the thoracic duct. These lymphatic vessels take origin in the lymphatic spaces of the tissues, and in the walls of serous cavities, and they usually run alongside blood-vessels—*perivascular lymphatics.* They have a structure similar to that of veins, but are more abundantly provided with valves. Along the course of the lymphatic trunks are certain structures known as *lymphatic glands.* These are composed of a reticulated connective tissue, the spaces of which are packed with leucocytes, and they possess a definite capsule. The lymph in passing through a gland follows a tortuous course, whereby it is brought into intimate contact with the leucocytes in the gland. The action of the leucocytes on the lymph passing through the gland is of great physiological importance. The glands not only arrest inert substances, such as blood pigment circulating in the lymph, but also living elements, such as cancer cells or bacteria. In bacterial infections there is always a struggle between the organisms brought to the glands and the leucocytes contained in them, so that the glands may be looked upon as an important line of defence, preventing or retarding the passage of bacteria and their products into the general circulation. The infective agent must usually overcome the resistance of a whole chain of glands before reaching the blood-stream. In their attempt to repel organismal attacks, however, the glands themselves often succumb to the infection, and the common diseases of lymphatic glands are thus brought about.

Lymphatic glands are, for the most part, arranged in groups or chains, such as those in the axilla, neck, or groin. They vary in number and size in different individuals in any given situation, and fresh glands may be formed on comparatively slight stimulus, and disappear when the stimulus is withdrawn. The best-known example of this is the increase in the number of glands in the axilla which takes place during lactation. When this function terminates many of the glands become involuted and are transformed into fat. In the event of a subsequent lactation or of a cancer appearing in the breast later in life, the glands are again developed. Glands which have been removed by operation are readily re-formed, and after some time the newly formed glands are not distinguishable from the original ones. This depends on the fact that lymphatic glands, though apparently complicated, are really very simple in structure, and require nothing for their development or re-formation which is not present in any loose connective tissue. The necessary elements are lymphatic vessels with the connective tissue surrounding them, and blood-vessels. The leucocytes are brought both by the lymph-vessels and by the blood, and they become entangled in the meshes of the connective tissue.

Anatomical Distribution of Glands.—The more important groups of glands, and the areas which they drain, in the head and neck and in the upper and lower extremities, are as follows:—

Head and Neck.—*The parotid or pre-auricular glands* lie beneath the parotid fascia in front of the ear, and some are partly embedded in the substance of the parotid gland. They drain the parts about the temple, cheek, eyelids, and auricle. *The occipital gland* is situated over the origin of the trapezius from the superior curved line. It drains the top and back of the head. *The mastoid or posterior auricular glands* lie over the mastoid process. They drain the side of the head and auricle. These three groups pour their lymph into the cervical glands. *The submaxillary*—two to six in number—lie along the lower border of the jaw from the symphysis to the angle, the posterior ones being closely connected with the submaxillary salivary gland. They receive lymph from the face, lips, floor of the mouth, gums, teeth, anterior part of tongue, and the alæ nasi, and from the pre-auricular glands. The lymph passes from them into the deeper cervical glands. *The submental gland* lies in the middle line between the anterior bellies of the digastric muscles, and receives lymph from the lips. *The supra-hyoid* lies a little farther back, immediately above the hyoid bone, and receives lymph from the tongue. *The external jugular glands* lie along the external jugular vein. They are not always present. They receive lymph from the occipital and mastoid glands and from the auricle. *The sterno-mastoid glands*—glandulæ concatinatæ—form a chain along the posterior edge of the sterno-mastoid muscle, some of them lying beneath the muscle. They are commonly enlarged in constitutional syphilis. *The internal jugular glands,* commonly called the deep cervical,—from six to twenty in number,—form a continuous chain along the internal jugular vein, beneath the sterno-mastoid muscle. They drain the various groups of glands which lie nearer the surface, also the interior of the skull, larynx, trachea, thyroid, and lower part of the pharynx. They pour their lymph into the main lymphatic trunks at the root of the neck. Belonging to this group is one large gland which lies behind the posterior belly of the digastric, and rests in the angle between the internal jugular and common facial veins. It is commonly enlarged in affections of the tonsil and posterior part of the tongue. Belonging to the same group are three or four glands which lie entirely under cover of the upper end of the sterno-mastoid muscle, and surround the spinal accessory nerve before it perforates the muscle. *The supra-clavicular glands* lie in the posterior triangle, above the clavicle. They receive lymph from the lowest cervical glands, from the upper part of the chest wall, and from the highest axillary glands. They are frequently infected in cancer of the breast, occasionally also in cancer of the stomach. *The retro-pharyngeal glands* lie on each side of the middle line upon the rectus capitis anticus major muscle and in front of the prevertebral layer of the cervical fascia. When they are infected with pus organisms or with tubercle bacilli they may lead to the formation of a retro-pharyngeal abscess.

Upper Extremity.—*The epi-trochlear and ante-cubital glands* vary in number and in situation. That most commonly present lies about an inch and a half above the internal condyle. Other and smaller glands may lie along the internal bicipital sulcus or at the bend of the elbow. They drain the ulnar side of the hand and forearm, and pour their lymph into the axillary group. The epi-trochlear gland is often enlarged in syphilis. *The axillary glands* are arranged in three groups. A central group lie embedded in the axillary fascia, and are often related to an opening in it. A subscapular group lie along the line of the vessels of the subscapular vessels. A pectoral group lie behind the pectoralis minor, along the inner side of the axillary vein. The axillary glands receive lymph from the arm, mamma, and side of the chest, and pass it on into the lowest cervical glands and the main lymphatic trunk.

Lower Extremity.—*The popliteal glands* include one superficial gland at the termination of the short saphenous vein, and several deeper ones in relation to the popliteal vessels. They receive lymph from the toes and foot, and transmit it to the inguinal glands. *The femoral glands* lie vertically along the upper part of the internal saphenous vein, and receive lymph from the leg and foot. From them the lymph passes to the deep inguinal and external iliac glands. *The superficial inguinal glands* lie along Poupart's ligament, and receive lymph from the external genitals, anus, perineum, buttock, and anterior abdominal wall. The lymph passes on to the deep inguinal and external iliac glands. *The deep inguinal glands* lie on the inner side of the femoral vein, and sometimes within the crural canal. They receive lymph from the deep lymphatics of the lower limb, and some of the efferent vessels from the femoral and superficial inguinal glands. The lymph then passes on through the crural canal to the external iliac glands.

The glands of the thorax and abdomen will be considered with the surgery of these regions.

INJURIES OF LYMPHATIC VESSELS.

Lymphatic vessels are divided in all wounds, and the lymph which escapes from them is added to any discharge which may be present. In the case of larger trunks the lymph may escape in considerable quantity as a colourless, watery fluid—*lymphorrhagia;* and the opening through which it escapes is known as a *lymphatic fistula.* This has been chiefly observed after excision of the glands in the groin. When the lymphatic return from a limb has been seriously interfered with,—as, for example, when the axillary contents have been completely cleared out in operating for cancer of the breast,—a condition of *lymphatic œdema* may result, the arm becoming swollen, tight, and heavy.

Wounds of the Thoracic Duct.—The thoracic duct usually opens at the angle formed by the junction of the left internal jugular and subclavian veins, but it may open into either of these vessels by one, or by several channels, or the duct may be double throughout its course. There is a smaller duct on the right side—the right thoracic duct. The position of the duct may be altered by the presence of tumours, such as a mass of enlarged glands. In dissections at the root of the neck the duct may be accidentally wounded, and jets of milky fluid—chyle—may at once escape from it. The injury is, however, seldom recognised at the time of operation; more commonly the dressings are found to be soaked with chyle—*chylorrhœa*. If the wound involves the only existing main duct and all the chyle escapes, the patient may die of inanition; but if only one of several collateral channels is implicated, the loss of chyle may be of little moment as the discharge usually ceases spontaneously. If the skin wound is sutured and heals, a fluctuating swelling may form beneath the scar, and in course of time gradually disappear.

In treating an accidental wound of the duct, if it is not possible to close it with sutures, it should be seized with forceps and ligatured as if it were a bleeding artery. The tissues are then stitched over it and the skin wound accurately closed, so as to obtain healing by first intention. Firm pressure should be applied by dressings and a bandage. Even if the main duct is obliterated, a collateral circulation is usually established. The patient should be fed on a diet rich in fat and egg albumin to promote a copious flow of chyle, and so encourage the establishment of a collateral circulation. A wound of the main lymphatic duct on the right side is of less importance.

Subcutaneous rupture of the thoracic duct may result from a crush of the thorax. The chyle escapes and may accumulate in the cellular tissue of the posterior mediastinum and behind the peritoneum, in the pleural cavity (*chylo-thorax*), or in the peritoneal cavity (*chylous ascites*). There are physical signs of fluid in one or other of these situations, but the nature of the lesion is only recognised when chyle is withdrawn by the aspirating needle.

Diseases of Lymphatic Vessels.

Lymphangitis.—Inflammation of lymphatic vessels usually results from the entrance of pyogenic bacteria or their products from some primary source of infection in the skin. This may be a septic wound or a purulent blister, and the streptococcus pyogenes is the organism most frequently present. Lymphangitis is commonly met with in pathologists, butchers, and others who handle infective material.

The inflammation chiefly affects the walls of the vessels and is attended with clotting of the lymph. There is also some degree of inflammation of the surrounding tissues—*peri-lymphangitis.* One or more abscesses may form along the course of the affected vessels, or a spreading cellulitis may supervene.

The *clinical features* resemble those of other acute pyogenic infections. There are also wavy red lines running from the source of infection towards the nearest lymphatic glands. These correspond to the inflamed vessels, and are the seat of throbbing pain and tenderness. The associated glands are enlarged and painful. In severe cases the symptoms may merge into those of septicæmia. When the deep lymphatics are involved, the superficial red lines are absent and the limb is œdematous.

In cases of extensive lymphangitis, especially where there are repeated attacks, the vessels may be obliterated and a persistent solid œdema result, constituting one of the varieties of elephantiasis.

Treatment.—The primary source of infection is dealt with on the usual lines. The patient is confined to bed, and the affected limb is elevated on a pillow. The area in relation to the inflamed lymphatics is enveloped in a fomentation of weak carbolic—1 in 60—or of lead and opium. If suppuration occurs, the pus must be evacuated. If the infection is due to the streptococcus pyogenes, the anti-streptococcic serum may be injected. When the inflammation has subsided, the limb is massaged and evenly bandaged to prevent œdema.

Tuberculous Lymphangitis.—This is chiefly met with in relation to tuberculous lesions of the skin of the extremities, such as lupus, inoculation tubercle, and sinuses resulting from dactylitis. The infection spreads upwards along the superficial lymphatics, which become nodularly thickened, while at one or more points larger, peri-lymphangitic nodules, which tend to break down into abscesses and ulcers, may form. When the disease is widely distributed throughout the lymphatics, the limb may become swollen and hard—a condition illustrated by lupus elephantiasis.

Treatment must be directed both to the original source of infection and to the diseased lymphatics.

Syphilitic lymphangitis is observed chiefly in the vessels of the dorsum of the penis. These may be felt as indurated cords in some cases of primary syphilis.

In addition to serving as channels for the conveyance of bacterial infection, *lymphatic vessels frequently convey the cells of malignant tumours*, and especially cancer, from the seat of primary growth to the nearest lymphatic glands. This fact is of great importance in relation to the operative treatment of cancer.

Lymphangiectasis is a dilated or varicose condition of lymphatic vessels. It is sometimes met with as a congenital condition in the tongue and lips, and it may be acquired as the result of any condition which is attended with extensive obliteration or blocking of the main lymphatic trunks. The most important type of lymphangiectasis is that resulting from the presence of filariæ in the vessels, and which is chiefly observed in the groin, spermatic cord, and scrotum.

Filarial disease in the lymphatics of the groin appears as a soft, doughy swelling, varying in size from a walnut to a cocoa-nut, which may partly disappear on pressure and on lying down.

There may be no other symptoms, or the patient may give a history of feverish attacks during which the swelling becomes painful and tender. These attacks may show a remarkable periodicity, and each may be followed by an increase in the size of the swelling. The swelling may be continued along the inguinal canal into the abdomen, or down the spermatic cord into the scrotum. On dissection the swelling is found to be made up of dilated, tortuous, and thickened lymphatic vessels, in which the parent worm is sometimes found, and of greatly enlarged lymphatic glands which have become converted into a tough, spongy tissue, the spaces of which are filled with lymph. The fluid in the dilated vessels is either clear or turbid, in the latter case resembling chyle. The affection is frequently bilateral, and may be associated with lymph scrotum, with elephantiasis, and with chyluria.

The *diagnosis* is to be made from other swellings in the groin, such as hernia, lipoma, or cystic pouching of the saphena vein. It is aided by obtaining the history that the patient has lived in the tropics, and by finding the embryo of the filaria sanguinis hominis in the blood.

Treatment.—This is influenced by whether the disease is limited to the groin or scrotum, or whether it is generalised throughout the body. Opinion is divided as to the advantages of excision, even in the localised disease. While on the one hand it may bring about a permanent cure, especially if the adult worms are found in the dilated lymphatics which are removed, on the other it may result in the formation of lymphatic sinuses and only afford temporary relief. Where operation is contra-indicated, relief may be afforded by the use of a pad and elastic bandage.

Lymphangioma bears the same relation to lymph-vessels as angioma bears to blood-vessels. It consists of cavities and channels filled with lymph, which freely communicate with one another. Their walls are composed of fibro-areolar tissue, lined by endothelium, and sometimes strengthened by non-striped muscle. The cavities result either from the new formation of lymphatic spaces and vessels, or from the dilatation of those which already exist. When the tumour is made up of a meshwork of cavities and channels, it is called a *cavernous lymphangioma*: when it is composed of one or more separate cysts, it is called a *cystic lymphangioma* or *lymphatic cyst*. It is probable that the cysts are derived from the caverns by the breaking down and absorption of the intervening septa, and transition forms between the cavernous and cystic varieties are frequently met with. They are probably all of congenital origin, and they usually appear at or shortly after birth. They are rarely provided with a definite capsule, and they frequently send prolongations of their substance between and into muscles and other structures in their vicinity.

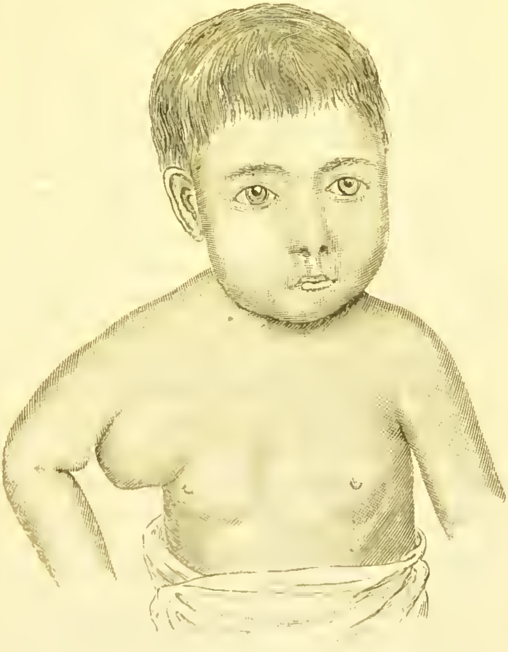

Fig. 53.—Congenital Cystic Tumour or Hygroma.

The cavernous lymphangioma appears as an ill-defined soft swelling presenting many of the characters of the subcutaneous angioma, but it is not capable of being emptied by pressure, the skin over it is normal, and when the tumour is punctured with an exploring needle it yields lymph instead of blood. It may also resemble a congenital lipoma, especially that growing from the periosteum, and the differential diagnosis is rarely completed until the swelling is punctured or explored by operation.

The cystic lymphangioma presents all the features of a cystic tumour. It is most often met with in the neck, springing from beneath the deep fascia, and projecting either in front of or behind the sterno-mastoid. It may attain a very large size, in which case the cyst wall may be so thin as to be translucent. It is also known under the names of *hydrocele of the neck* and *congenital cystic hygroma.* When it occurs on the floor of the mouth, it constitutes one form of ranula. It is also met with in the axilla (Fig. 53). These swellings are distinguished from dermoids by their having thinner walls, and in being less definitely circumscribed. A remarkable feature is the tendency they present to attacks of inflammation, which are usually followed by shrinkage and disappearance of the swelling. Sometimes the cystic variety is converted into an abscess—another, although less desirable method of cure. Those situated in the neck are most liable to become inflamed, probably because of pyogenic infection being brought to them by lymphatic vessels from the scalp, ear, or throat. The frequency of spontaneous cure explains the rarity of such cysts after puberty.

Treatment.—The cavernous lymphangioma may be left alone, or may be subjected to electrolysis or excision. Complete excision is rarely possible, because of the want of definition and encapsulation. The cystic form may be injected with iodine or tapped and drained, or it may be excised.

Diseases of Lymphatic Glands.

Lymphadenitis.—Inflammation of lymphatic glands usually results from the absorption of an irritant, usually bacterial or toxic, brought to the glands by the afferent lymphatics. These vessels may share in the inflammation and be the seat of lymphangitis, or they may show no evidence of the passage of the irritant. It is exceptional for the irritant to be carried to the gland in the blood-stream.

Strain or other form of trauma is sometimes blamed for the onset of lymphadenitis, especially in the glands of the groin, but it is usually possible to discover some source of pyogenic infection which is responsible for the mischief, or to obtain a history of some antecedent affection such as gonorrhœa. It is possible that gonococci may lie latent in the inguinal glands for long periods, and only give rise to lymphadenitis if the glands be subjected to injury.

The term *bubo* is sometimes applied to an inflamed gland. The glands most frequently the seat of inflammation are those in the neck, axilla, and groin.

The characters of the inflammation vary with the nature of the irritant giving rise to it. Sometimes it is mild and evanescent, as in the glandular enlargement in the neck which attends tonsillitis and certain other forms of sore throat. Sometimes it is more persistent, as in the enlargement which may be associated with adenoids, hypertrophied tonsils, carious teeth, eczema of the scalp, and otorrhœa; and it is probable that this indolent enlargement predisposes to tuberculous infection. A similar enlargement is met with in the axilla in cases of chronic interstitial mastitis, and in the groin as a result of chronic irritation about the external genitals.

Sometimes the inflammation is of a more acute character, and the tendency is towards the formation of an abscess. This is illustrated in the axillary glands inflamed as a result of infected wounds of the fingers, in the femoral glands in infected wounds or purulent blisters on the foot, in the inguinal glands in gonorrhœa and soft chancre, and in the cervical glands in the severer forms of sore throat associated with diphtheria and scarlet fever. The most acute glandular suppurations are those which result from infection with streptococci.

Superficial glands, when inflamed and suppurating, become enlarged, tender, fixed, and matted to each other. In the glands of the groin the suppurative process is often remarkably sluggish. Purulent foci form in the interior of the individual glands, and some time may elapse before the pus erupts through their respective capsules. In the deeply placed cervical glands, especially in cases of streptococcal throat infections, the suppuration rapidly involves the surrounding cellular tissue, and the clinical features are those of an acute cellulitis and deeply seated abscess. When this is incised the necrosed glands may be found lying in the pus, and on bacteriological examination are found to be swarming with streptococci. In suppuration of the axillary glands, the abscess may be quite superficial, or it may be deeply placed beneath the strong fascia and pectoral muscles, according to the group of glands involved.

The *diagnosis* of septic lymphadenitis is usually easy. The indolent enlargements are not always to be distinguished, however, from commencing tuberculous disease, except by the fact that they usually disappear on removing the peripheral source of irritation.

Treatment.—Having removed the original source of infection, the treatment applicable to the glands varies according to the nature and degree of the inflammation. Rest and soothing applications are indicated in the early stage of inflammation. Glycerine and belladonna, or the oleate of mercury ointment, is useful in indolent enlargements; lead and opium or carbolic fomentations in the more acute forms of lymphadenitis. If suppuration has taken place and is confined to the glands, as in the groin, each focus should be attacked with the knife, spoon, and pure carbolic acid, or the whole chain of glands may be excised. If, on the other hand, there is a large peri-glandular abscess, as is often the case in the neck and axilla, this should be opened—preferably by Hilton's method. The opening should be enlarged to admit the finger and allow of the removal of any glands which have not completely broken down, and which probably contain other foci of suppuration. If the suppurative bubo associated with soft chancre be simply incised, the tendency is towards the formation of an inflamed ulcer resembling the original sore. It is better, therefore, to excise the gland along with the infiltrated and undermined skin, unless there is already a considerable abscess, in which case it should be incised, scraped, painted with pure carbolic acid, and packed with iodoform worsted.

Tuberculous Disease of Glands.—This is a disease of great frequency and importance. The tubercle bacilli usually gain access to the glands through the afferent lymphatic vessels which are infected through some lesion of the mucous or skin surface in the area drained by them. It is possible, however, that the organisms are sometimes carried to the glands by the blood-stream. The tuberculous infection may supervene in glands which are already enlarged as a result of chronic septic irritation, or in glands which are otherwise healthy. While any of the glands in the body may be affected, the disease is most often met with in the groups of cervical glands which derive their lymph from the mouth, nose, throat, ear, and scalp.

The appearance of the glands on section varies with the stage of the disease. In the earliest stages the gland is enlarged, it may be to many times its natural size, is normal in colour, and firm in consistence. On microscopical examination there is evidence of tuberculous infection in the shape of bacilli and of characteristic giant and epithelioid cells. At a later stage the gland tissue is studded with yellow caseating foci which tend to enlarge and to become confluent, so that the whole gland is converted into a caseous mass surrounded by the thickened capsule. The caseated tissue may become calcified, but more frequently it liquefies and breaks down into tuberculous pus.

Disease in the cervical glands is a common accompaniment or sequel of adenoids, enlarged tonsils, carious teeth, pharyngitis, middle-ear disease, conjunctivitis, and suppurative lesions of the scalp, such as impetigo. These lesions afford the bacilli a chance of entry into the lymphatics, in which they are carried to the glands of the neck, where they give rise to tuberculous disease.

In the cervical glands the enlargement may affect only one gland, usually below the angle of the jaw, and may remain confined to it. The enlarged gland is painless, firm, ovoid, and varies in size from a hazel nut to a walnut. More commonly the disease affects several glands, spreading from one to another on one and sometimes on both sides of the neck. When the disease commences in the pre-auricular or submaxillary glands, it tends to spread to those along the carotid sheath. When the posterior auricular and occipital glands are first involved, the spread is towards those along the posterior border of the sternomastoid. In many cases all the various chains in front of, beneath, and behind this muscle are involved, the enlarged glands extending from the mastoid to the clavicle. When several glands are affected, they are at first discrete and movable, and may even vary in size from time to time, but with the addition of peri-adenitis they become fixed and matted together, forming large lobulated or nodular masses. They not only become adherent to one another, but also to the structures in their vicinity,—skin, fascia, muscles, veins, and nerves,—a point of considerable importance in regard to their removal by operation.

The tuberculous disease in the interior of the glands may undergo cicatrisation and cure. Much more commonly, however, it caseates, and although this may result in calcification and arrest of the disease, it more frequently terminates in liquefaction and suppuration, in which case the tubercle bacilli may have been reinforced by the penetration of other organisms. The result is an abscess, which is usually of the cold variety, but which may partake of the more active features of the pyogenic type. The transition from the solid to the liquefied stage of the disease is attended with pain and tenderness in the gland, which at the same time becomes more fixed—especially to the skin—and more globular. Finally it becomes elastic and yields fluctuation.

If left to itself the softened tubercle erupts through the capsule of the gland and infects the cellular tissue. The cervical fascia is perforated, and a cold abscess, often much larger than the gland from which it took origin, forms between the fascia and the overlying skin. The further stages—undermining of skin and external rupture, with the formation of ulcers and sinuses—have been described with tuberculous abscess. The ulcers and sinuses may persist indefinitely, or may heal up for a time and then break out afresh; and sometimes the skin becomes the seat of tuberculous disease, which may spread like lupus, especially in the submaxillary region, until it eventually extends from ear to ear. Healing may finally take place, but the resulting scars are extremely unsightly, being puckered or bridled, or even highly coloured and hypertrophied like keloid.

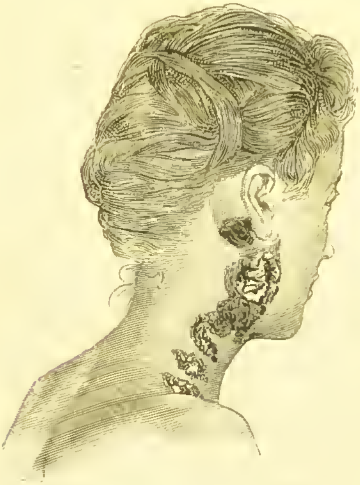

FIG. 54.—Ulceration of Skin resulting from the breaking down of Tuberculous Cervical Glands.

While the disease is most common in childhood and youth, it may be met with even in advanced life. Although commonly associated with depraved health and unhealthy surroundings, it may affect those who are apparently robust and in affluent circumstances.

Diagnosis.—Tuberculous disease is differentiated from the glandular enlargement which results from septic irritation by its persistence after all sources of irritation have been removed. It is rarely possible to differentiate tuberculous disease from lymphadenoma and from lymphosarcoma at a stage when a positive diagnosis would be of real value, unless a gland is excised and submitted to microscopical examination. The subsequent progress usually clears up the diagnosis. Signs of liquefaction and suppuration in the glands indicate the tuberculous nature of the disease.

Glandular enlargement from secondary cancer may closely simulate tuberculosis,—especially when the cancerous glands have undergone liquefaction,—but is to be differentiated by its association with cancer in the mouth, throat, or other adjacent part, and by the early induration and fixation of the glands affected.

Cold abscess resulting from tuberculous glands is to be differentiated from that due to disease in the cervical spine, as well as from congenital and other cysts in the neck.

Prognosis.—Next to lupus, glandular disease is of all tuberculous lesions the least dangerous to life. Nevertheless, a large proportion of those who suffer from it in childhood or youth afterwards suffer from tuberculous disease in bones and joints and in internal organs, especially the lungs. So far as the disease in the glands is concerned, the prognosis is materially influenced by the social circumstances of the patient and by the treatment adopted.

Treatment.—The morbid conditions vary so widely in different cases that no one line of treatment can be expected to suffice in all. Every case must be considered and treated on its own merits. The extent of the disease, its duration and progress, the previous treatment and its results, and the general health and surroundings of the patient must all be taken into account.

When seen in the early stages, before there are any signs of liquefaction in the gland, the condition is treated by removing any peripheral irritation in the mouth or throat, and improving the general health by fresh air, good food, and cod-liver oil. Arsenic is useful in diminishing the peri-adenitis. External applications such as iodine or mercurial ointment are of doubtful value. A wire or felt splint may be employed to restrain the movements of the head and neck, but in most cases it is sufficient to apply cotton wool and a bandage.

When seen at a later stage, when, in spite of the above treatment, the glandular enlargement persists, and especially if it is on the increase, and there is involvement of fresh glands, their removal by operation should be recommended.

When there are *signs of liquefaction* in the gland, or of a *cold abscess* in the tissues around, operative interference should be had recourse to without delay, in order to hasten the reparative process and to diminish the amount of disfigurement.

The operative treatment varies with the condition of the glands. A mass of enlarged glands is excised after the same method as in the removal of an innocent tumour; if liquefaction has taken place, the condition is dealt with like a cold abscess. Where there is a combination of enlarged glands and abscesses, the latter are dealt with first, and the glands are excised either at the same operation or after an interval. Where there are sinuses these are excised or scraped, and all diseased skin is cut away, in addition to getting rid of the disease in the glands.

The excision of tuberculous glands is often an extensive and difficult operation, because of the number and deep situation of the glands to be removed, and because of the adhesions to surrounding structures. The skin incision must be sufficiently extensive to give access to the whole of the affected area, and should, whenever possible, be made in the line of the natural creases of the skin. Where glands are to be removed from both anterior and posterior triangles, the best access is obtained by a Z-shaped incision, the upper limb running parallel with the lower jaw, the vertical limb along the sterno-mastoid, and the lower limb parallel with the clavicle. In exposing the glands the common facial and other venous trunks may require to be clamped and ligatured. Care must be taken to preserve the important nerves, particularly the spinal accessory, the vagus, and the phrenic. The inframaxillary branches of the facial, the hypoglossal and its descending branches, and the motor branches of the deep cervical plexus are liable to be injured, and should, if possible, be conserved. In the removal of matted glands beneath the sterno-mastoid it may be necessary to cut this muscle across and to reflect the divided ends upwards and downwards; if the muscle itself is infiltrated with tubercle, it is removed along with the glands. When the glandular mass is closely adherent to the internal jugular vein, the operation is rendered easier by ligaturing the vein at the root of the neck and removing it from below upwards along with the glands (Watson-Cheyne). When the glands are affected on both sides of the neck it may be advisable to allow an interval to elapse rather than to operate on both sides at one sitting.

The "scraping" of softened glands and peri-glandular abscesses, although a useful and often a very necessary operation, is not only less certain of permanently curing the patient, because diseased tissue is apt to be left behind, but it is liable to be followed by dissemination of the tuberculous infection, and general tuberculosis. In opening a glandular abscess the incision should be large enough to allow of its interior being inspected; it is then possible to introduce the spoon into the various pockets, and especially through the opening in the deep fascia leading down to the gland from which the abscess originated. Success depends on the thoroughness with which all the tuberculous tissue is removed. The wall of the resulting cavity is painted over with pure carbolic acid, and the wound is packed with iodoform worsted. The packing is renewed at intervals until the wound heals.

Tuberculous disease *in the axillary glands* may be met with as a result of extension from the glands in the neck, from tuberculous disease of the mamma, ribs, or sternum, or more rarely from tuberculous disease in the fingers or arm. Sometimes it is impossible to discover the source of infection, in which case one can only assume that it has taken place through the blood-stream. The glands frequently attain a large size, and are usually freely movable. The treatment consists in removing them by an operation similar to that employed in clearing out the contents of the axilla in cases of cancer of the breast.

In the *glands of the groin* tuberculous disease is comparatively rare. We have chiefly observed it in the femoral glands as a result of inoculation tubercle on the toes or sole of the foot. The affected glands tend to break down and suppurate, and after destroying the overlying skin they give rise to fungating tuberculous ulcers.

The treatment consists in excising the glands and the affected skin. The dissection is often attended with troublesome hæmorrhage from the numerous veins which converge towards the common femoral trunk.

Tuberculous affections of the mesenteric and bronchial glands will be referred to later.

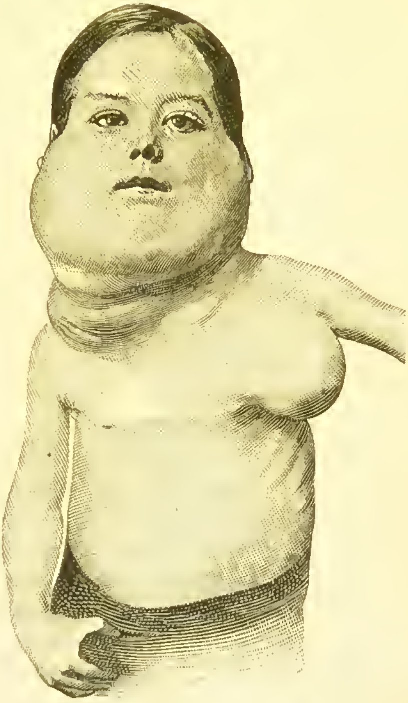

FIG. 55.—Hodgkin's Disease in a boy aged 5.

(From Byrom Bramwell's *Atlas of Clinical Medicine.*)

Syphilitic Disease of Glands. — Enlargement of lymphatic glands is a prominent feature in acquired syphilis, especially in the form of the indolent or bullet-bubo, which so commonly accompanies the primary sore, and the general enlargement of glands which occurs throughout the body in secondary syphilis. Gummatous disease in glands is extremely rare.

Lymphadenoma — *Hodgkin's Disease.* — This is a disease which is usually met with in males below middle age. It begins as a slow, painless enlargement of some particular group of glands, most commonly those in the cervical region. The glands are usually larger than in tuberculosis, and they remain longer discrete and movable. In time the glandular masses may form enormous projecting tumours, the swelling being added to by œdema of the overlying cellular tissue and skin (Fig. 55).

The enlargement spreads along the cervical chain of glands to those above the clavicle, to those in the axilla, and to those of the opposite side. Later the glands in the groin can be seen and felt to be enlarged. It is probable that the infection has spread from the glands in the neck along the mediastinal, bronchial, retro-peritoneal, and mesenteric glands, and has branched off from thence to the iliac and inguinal groups.

When the disease has thus become generalised, the patient's health suffers and he becomes feverish and anæmic. The blood presents the characters met with in secondary anæmia, and although leucocytosis may be observed at any stage, it is not an essential feature of the disease. The spleen, liver, testes, and mammæ may be enlarged. The glandular swellings may press on important structures, such as the trachea, œsophagus, or great veins, and give rise to symptoms referable to such pressure. The disease usually terminates fatally within one or two years of its commencement. The structural changes in the lymphatic glands are not characteristic of any specific infection. The glands are hypertrophied, and the lymph spaces are crowded with leucocytes, while in the later stages the fibrous framework of the gland becomes thickened. The origin of the disease is as yet unknown, but analogy would suggest that it is due to infection with a slowly growing micro-organism.

Diagnosis.—The true relationships of lymphadenoma to lymphosarcoma and to leucocythæmia are as yet imperfectly established, so that it is impossible to state definitely the points upon which a differential diagnosis may be founded. True leucocythæmia is to be recognised by the characteristic alterations in the blood. Lymphosarcoma runs a clinical course similar to that of other forms of sarcoma. The diagnosis from tuberculosis at an early stage can only be made by removing one of the glands and submitting it to examination.

Treatment.—In genuine cases of lymphadenoma treatment is of little avail. Arsenic is given in full doses either by the mouth or by subcutaneous injection. The excision of glands, although sometimes beneficial, seldom arrests the progress of the disease. Surgical interference may give relief where important structures are being pressed upon—tracheotomy, for example, may be required where life is threatened by asphyxia.

Leucocythæmia.—This is a disease of the blood and of the blood-forming organs in which there is a great increase in the number, and an alteration of the character of the leucocytes present in the blood. It may simulate lymphadenoma, because, in certain forms of the disease, the lymphatic glands, especially those in the neck, axilla, and groin, are greatly enlarged, and there is a gradual failure of health terminating in death.

TUMOURS OF LYMPHATIC GLANDS.

Primary Tumours.—It is very doubtful if there exists an *innocent lymphoma* or simple hypertrophy of glands apart from the diseased conditions already described.

The *malignant lymphoma* or *lympho-sarcoma*, which cannot always be differentiated from lymphadenoma, may be regarded as a sarcoma starting in lymphatic glands. It appears in the neck, axilla, or mediastinum, as a rapidly growing tumour consisting of one or more enlarged glands with numerous satellites. As the tumour increases in size, the sarcomatous tissue erupts through the capsule of the glands, and infiltrates the surrounding tissues.

The only treatment is early excision, but the results are most disappointing.

Secondary Tumours.—Next to tuberculosis, *secondary cancer* is the most common and most important disease of lymphatic glands. It is met with in the neck in association with epithelioma of the lip, tongue, or throat. The glands form tumours of variable size, and are often larger than the primary growth, the characters of which they reproduce. The glands are at first hard and movable, but soon become fixed, and in time they soften, liquefy, and burst through the skin, forming foul, fungating ulcers. A similar affection is met with in the groin from epithelioma of the penis, scrotum, or vulva. In cancer of the breast, the affection of the axillary glands is an important complication.

In *pigmented* or *melanotic cancers* of the skin, the glands are early infected and increase rapidly, so that when the primary growth is still of small size,—as, for example, on the sole of the foot,—the femoral glands may already constitute large pigmented tumours.

The implication of the glands in other sites and varieties of cancer will be considered with regional surgery.

Secondary sarcoma is seldom met with in glands except when the primary growth is situated in the tonsil, thyroid, or testicle.

CHAPTER XVI.

THE NERVES.

Anatomy—WOUNDS OF NERVES: Changes in nerves after division; Repair and its modifications; Clinical features; *Primary and secondary suture*—SUBCUTANEOUS INJURIES OF NERVES—DISEASES: *Neuritis; Tumours*—Surgery of the individual nerves: *Brachial neuralgia; Sciatica; Trigeminal neuralgia.*

Anatomy.—A nerve trunk is made up of a variable number of bundles of nerve fibres surrounded and supported by a framework of connective tissue. The nerve fibres are chiefly of the medullated type, and they run without interruption from a nerve cell or "neuron" in the brain or spinal cord to their peripheral terminations in muscle, skin, and secretory glands.

Each nerve fibre consists of a number of nerve fibrils collected into a central bundle—the axis cylinder—which is surrounded by an envelope, known as the neurilemma or sheath of Schwann. Between the neurilemma and the axis cylinder is the medullated sheath composed of a fatty substance known as myelin. This medullated sheath is interrupted at the nodes of Ranvier, and in each internode is a nucleus lying between the myelin and the neurilemma. The axis cylinder is the essential conducting structure of the nerve, while the neurilemma and the myelin act as insulating agents. The axis cylinder depends for its nutrition on the central neuron with which it is connected, and from which it originally developed.

The connective-tissue framework of a nerve trunk consists of the *perineurium*, or general sheath, which surrounds all the bundles; the *epineurium*, surrounding individual groups of bundles; and the *endoneurium*, a delicate connective tissue separating the individual nerve fibres. The blood-vessels and lymphatics run in these connective-tissue sheaths.

INJURIES OF NERVES.

Nerves are liable to be injured in various ways: thus they may be cut or torn across, bruised, compressed, stretched, or torn away from their connections with the spinal cord. *Complete division* is a common result of accidental wounds, especially in the forearm, where the ulnar, median, and radial nerves are frequently cut across.

The mere interruption of the continuity of a nerve may result in degeneration of its fibres; the myelin being broken up into droplets and absorbed, while the axis cylinders swell up, disintegrate, and finally disappear. Both the conducting and the insulating elements are thus lost. The degeneration in the central end of the divided nerve is limited to the immediate proximity of the lesion, and does not involve all the nerve fibres. In the distal end it is generally believed to extend throughout the entire peripheral distribution of the nerve, because the fibres are cut off from their trophic nerve cells in the spinal cord. The amount of degeneration, however, would appear to depend largely upon whether the ends are reunited or not, and on the length of time they remain apart. If there is a gap left between them, or if they are separated by scar tissue, the peripheral end undergoes complete degeneration in from six weeks to two months. If, however, the ends are in contact, degeneration may take place only to a very limited extent, or not at all.

Process of Repair when the Ends are in Contact.—*If the wound is aseptic*, the ends of the divided nerve become united, and the conducting paths are established by a regeneration of nerve fibres. There is a difference of opinion as to the method of regeneration. According to one view, the divided axis cylinders in the central end grow downwards and subdivide, forming new axis cylinders, which enter the nerve sheaths of the distal portion, and continue growing until they reach the peripheral terminations in muscle and skin. In course of time they acquire a myelin sheath. In this way both conduction and insulation are completed, and messages may then be transmitted between the central nervous system and the periphery. This method of regeneration is necessarily slow because of the distance to be traversed by the down-growing axis cylinders. The other and more probable view is that the formation of new axis cylinders is not confined to the central end, but that it goes on also in the peripheral segment from the nuclei lying beneath the neurilemma. The new axis cylinders do not attain maturity, however, until continuity with the central end has been re-established.

When a nerve has been divided accidentally in the course of an operation—for example, the ulnar nerve, in excising the elbow—the immediate suture of the ends may be followed by the restoration of conduction within a few days. It would appear, therefore, that the changes which take place vary according to the interval of time which elapses between the division of the nerve and the approximation and union of its ends.

If the wound becomes infected before union is completed, the young tissue between the ends is converted into scar tissue, the conducting paths are not reproduced, and a condition similar to that described under the next heading results.

When the **ends of the divided nerve are not in contact**, reunion of the divided nerve fibres does not take place whether the wound is septic or aseptic. Between the ends there is a mass of newly-formed connective tissue, which varies in amount according to the duration of the reparative process and the length of time the ends remain apart. The proximal end of the nerve forms a bulbous swelling, which becomes adherent to the general scar tissue, and consists of branching axis cylinders running in all directions. These have failed to reach the distal end because of the distance between them. The peripheral end is completely degenerated, and is represented by a fibrous cord, the cut end of which is often slightly swollen or bulbous, and is also incorporated with the general scar tissue of the wound.

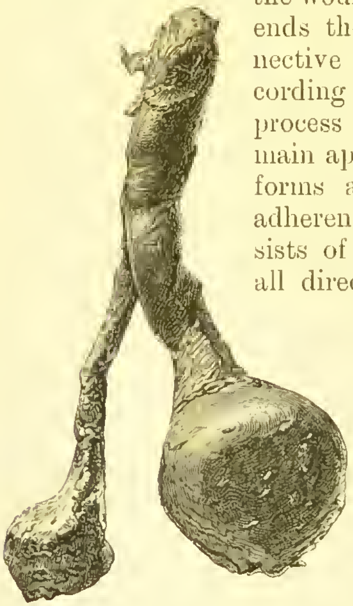

FIG. 56.—Stump Neuromata of Sciatic Nerve, excised forty years after the original amputation by Mr. A. G. Miller.

In the case of *nerves divided in an amputation* there is an active, although necessarily abortive, attempt at regeneration, which results in the formation of bulbous swellings at the cut ends of the nerves. When there has been suppuration, and especially if the nerves have been cut low down so as to be exposed in the wound, these bulbous swellings may attain an abnormal size, and are then known as "amputation" or "stump neuromata."

When a nerve is only *partially divided*, those fibres which are severed form new axis-cylinder processes, which are conducted across the gap by the intact fibres.

When a nerve is *torn across* or is badly *crushed*—as, for example, by a fractured bone—the changes are very similar to those in a divided nerve, and the ultimate result depends on the amount of separation between the ends and the possibility of the young axis cylinders bridging across the gap.

In *bruises and contusions*, hæmorrhages take place into the connective-tissue sheaths, and certain of the damaged nerve fibres may undergo degeneration.

Symptoms resulting from Division and Non-Union of a Nerve Trunk.—These necessarily vary with the functions of the affected nerve. We shall take as an example a mixed sensori-motor trunk, such as the median or musculo-spiral.

Sensory Phenomena.—There is loss of sensibility to touch, pain, and temperature. The loss of sensation is often incomplete, and the margins of the anæsthesic area are rarely sharply defined, and do not always correspond to the normal distribution of the nerve, doubtless because sensory impulses may be transmitted through collateral nerves.

If the nerve is incompletely divided there may be pain and hyperæsthesia, the pain being often referred to the terminal distribution of the nerve involved.

Motor Phenomena.—There is immediate and complete loss of voluntary power in all the muscles supplied by the divided nerve. The muscles rapidly waste, and usually within three or four days they cease to react to the faradic current. They soon present the "reaction of degeneration," which consists in a loss of excitability to the faradic current, along with a reversal of the normal polar reactions. After a few weeks all electric excitability is lost. The paralysed muscles undergo fatty degeneration, which attains its maximum three or four months after the division of the nerve. Further changes may take place, and result in the transformation of the muscle into fibrous tissue, which may cause shortening and deformity known as *paralytic contracture.*

Vasomotor Phenomena.— In the majority of cases there is an initial rise in the temperature of the part (2° to 3° F.), with redness and increased vascularity. This is followed by a fall in the local temperature, which may amount to 8° or 10° F., the parts becoming pale and cold. Sometimes the hyperæmia resulting from vasomotor paralysis is more persistent, and is associated with swelling of the parts from œdema—the so-called *angio-neurotic œdema.* The vascularity varies with external influences, and in cold weather the parts present a bluish appearance.

Trophic Phenomena.—Owing to the disappearance of the subcutaneous fat, the skin is generally smooth, thin, and glossy. It may be abnormally dry, and the sweat glands may to a great extent disappear. The hair is harsh, dry, and easily shed. The nails may become brittle and furrowed, or thick and curved.

Skin eruptions, especially in the form of herpetic blisters, may occur, or there may be actual ulcers of the skin, especially in the winter months (Fig. 13). In aggravated cases the tips of the fingers may disappear from progressive ulceration, and in the sole of the foot the condition may assume the characters of the perforating ulcer. Arthropathies are occasionally met with, the joints becoming the seat of a painless effusion or hydrops, which is followed by fibrous thickening of the capsular and other ligaments, and terminates in stiffness and fibrous ankylosis. The fingers may be seriously crippled and deformed.

The student must be prepared to meet with cases in which the symptoms fall far short of what might have been expected from the functions of the divided nerve. This is notably the case in the sciatic, where, in spite of the removal of a considerable portion of the nerve, the motor and sensory disabilities are sometimes recovered from to the extent that the patient is able to walk without support

Treatment of Divided Nerves.—The treatment consists in approximating the divided ends of the nerve and placing them under the most favourable conditions for repair.

Primary Suture.—The reunion of a recently divided nerve is spoken of as primary suture, and for its success asepsis is essential. As the suturing of the ends of the nerve is extremely painful, a general anæsthetic is required. The wound must be enlarged in the long axis of the affected nerve, as the ends—especially the proximal end—are usually retracted. Having identified the ends and brought them into contact, they are secured to each other by the finest chromicised catgut or silk passed by a round needle, such as is used for the intestine. The sutures are made to transfix the ends of the nerve and the sheath, and should only be drawn tight enough to obtain accurate apposition. Additional sutures may be passed through the sheath around the circumference. If the ends of the nerve are bruised or torn, fresh surfaces should be obtained by cutting them across. If the nerve is only partially divided, it may be sufficient to pass a few sutures through the sheath. Tension on the sutures may be relieved by flexing adjacent joints and fixing the limb in a splint. When the wound is healed, measures are employed to maintain the nutrition of the damaged nerve and of the parts supplied by it, while waiting for the restoration of function. The limb is exercised, massaged, and douched, and protected from cold and other influences which may provoke trophic changes. The nutrition of the paralysed muscles is further improved by electricity. The galvanic current is employed, using at first a mild current of not more than five milliampères for about ten minutes, the current being made to flow downwards in the course of the nerve, with the positive electrode applied to the spine, and the negative over the affected nerve near its termination. It is an advantage to have a key in the circuit whereby the current can be opened and closed at intervals, so as to cause contraction of the muscles.

The results of primary suture, when it has been performed under favourable conditions, are usually satisfactory. Where the nerve has been sutured immediately after division, reunion of the divided ends may take place so rapidly that there may never be any paralytic phenomena. In cases where an interval of several hours has elapsed, recovery is usually very slow, one month being the shortest time recorded before restoration of function. Sometimes sensation returns within a few days, only to disappear again. When it returns permanently, sensation to touch reappears before that to pain and temperature. The return of voluntary motor power often precedes that of excitability to electrical stimulation. While confusion of sensory localisation is not uncommon, the transmission of impulses to muscles is usually most accurate. The recovery of function may be impaired if neuritis supervenes.

Primary suture should not be attempted so long as the wound shows signs of inflammation or suppuration, as it is almost certain to end in failure. The ends should be sutured, however, as soon as the wound is aseptic or has healed.

Secondary Suture.—The stitching of the ends of a nerve in a wound which has already healed is known as secondary suture. The operation of uniting a divided nerve is more difficult in a wound which has healed, because the ends are usually involved in scar tissue. An incision is made in the line of the nerve, and the cut ends sought for. If they cannot be identified in the scar tissue, they will be found at a little distance above and below, in their normal anatomical situation. The ends of the nerve, after being freed from the scar tissue, are trimmed with scissors and approximated by sutures as already described. If a tourniquet is employed, it should be removed as soon as the ends of the nerve have been isolated.

Results of Secondary Suture.—When secondary suture has been performed under favourable conditions the prognosis is good, but a much longer time is required for complete restoration of function than after primary suture—in the recorded cases the shortest time was three months, and the longest three years. Sensation is recovered first, but it seldom returns before three or four months. There then follows an improvement or disappearance of any trophic disturbances which may be present. Recovery of motion may be deferred for long periods,—rather because of the changes in the muscles than from want of conductivity in the nerve,—and if the muscles have undergone complete degeneration, it may never take place at all. While waiting for recovery, every effort should be made to maintain the nutrition of the damaged nerve and of the parts which it supplies by the measures already described.

If it is impossible to bring the ends into contact, recourse must be had to other methods. For example, the gap may be bridged across by strands of fine catgut or by a portion of nerve obtained from an animal or a recently amputated limb. When catgut is employed, it is a useful addition to slip a decalcified bone tube over the ends of the nerve and across the gap. The practice of turning down flaps from the ends of the nerve is of doubtful value, as such portions usually degenerate. The resection of a portion of bone so as to shorten the segment of limb concerned has been successfully practised in the upper arm (Annandale). When the gap between the ends is very wide, the ends may be spliced into the nearest intact nerve trunk—for example, the widely separated ends of the median nerve may be attached to the ulnar. The results of this procedure—which has been called *nerve implantation*—are often most satisfactory.

Injuries of nerves from modern rifle-bullets have been already described.

Involvement of Nerves in Scar Tissue.—A nerve trunk or the terminal filaments of a nerve may be dragged upon or compressed by scar tissue. The patient complains of neuralgic pains and of great sensitiveness in the region of the scar. The pain may radiate to distant parts, and may be associated with twitching of the muscles and in rare cases with epileptiform convulsions. Secondary changes of the nature of neuritis may occur in the nerve affected.

Treatment.—When terminal filaments are involved in a scar, it is best to dissect out the scar, and along with it the ends of the nerves pressed upon. The wound is then closed by bringing together the edges or by means of a flap of skin, or by Thiersch grafts, with the view of obtaining primary union. When a nerve trunk, such as the sciatic, is involved in a scar, the nerve must be exposed and freed from its surroundings, and then stretched so as to tear any bands of fibrous tissue which may have been overlooked.

When the nerves in an amputation stump have not been cut sufficiently short, they may become involved in the cicatrix, and it may be necessary, on account of pain, to free them from their adhesions, and to resect enough of the terminal portions to prevent them again becoming adherent. Where this is difficult, a portion may be resected from each of the nerve trunks at a higher level, and if this fails to give relief, a fresh amputation must be performed.

Subcutaneous Injuries of Nerves.—It is useful to distinguish between those cases of subcutaneous injury in which the compressing force acts gradually and comparatively gently, and those in which it acts abruptly and severely. The former class includes the compression paralysis of the nerves of the upper arm which results from sleeping with the arm resting on the back of a chair or the edge of a table—the so-called "drunkard's palsy"; and from the pressure of a crutch in the axilla—"crutch paralysis." It also includes paralysis from the pressure of a tourniquet, from tight bandages or splints, from the pressure exerted by a dislocated bone or by excessive callus, and from hyper-extension of the arm during anæsthesia.

In all these forms there is impaired sensation, rarely amounting to anæsthesia, marked muscular wasting, and diminution or loss of voluntary motor power, while—and this is a point of great importance—the normal electrical reactions are preserved. The prognosis is usually favourable, as spontaneous recovery is the rule within from one to three months. In some cases, however, neuritis supervenes, the muscles degenerate, the electrical reactions are altered, and recovery may be retarded or may fail to take place.

Injuries which act abruptly or instantaneously are illustrated in the crushing of a nerve by the sudden displacement of a sharp-edged fragment of bone, as may occur in comminuted fractures of the humerus. The symptoms include perversion or loss of sensation, motor paralysis, and atrophy of muscles, which show the reaction of degeneration from the eighth day onwards. The occurrence of the reaction of degeneration influences the prognosis, for it implies a nerve lesion which is probably incapable of spontaneous recovery.

The *treatment* varies with the cause and nature of the lesion. When, for example, a displaced bone or a mass of callus is pressing upon the nerve, steps must be taken to relieve the pressure, by operation if necessary. When there is reason to believe that the nerve is severely crushed or torn across, it should be exposed by incision, and, after removal of the damaged ends, should be united by sutures. When it is impossible to make a definite diagnosis as to the state of the nerve, it may be necessary to wait for a few weeks and watch the progress of the case. The subsidiary measures employed after primary suture are also to be persevered with.

Dislocation of Nerves.—This injury, which resembles the dislocation of tendons from their grooves, is seldom met with except in the ulnar nerve at the elbow. It may result from a direct blow, or from a muscular effort which causes stretching or laceration of the fascia which holds the nerve in its groove, and may be predisposed to by the groove being shallow as a result of imperfect development of the internal condyle of the humerus.

The nerve slips forward, and may be felt lying on the inner aspect of the condyle. It may retain this position, or it may slip backwards and forwards with the movements of the arm. The symptoms at the time of the displacement are a certain amount of disability at the elbow, and pain and tingling along the nerve, which are exaggerated by movement and by pressure. The symptoms may subside altogether, or a neuritis may develop with severe pain shooting up the nerve.

The dislocated nerve is easily replaced, but is difficult to retain in position. In recent cases the arm may be placed in the extended position and a pad applied over the condyle, care being taken to avoid pressure on the nerve. Failing relief, it is better to make a bed for the nerve by dividing the deep fascia behind the internal condyle and stitching the edges of the fascia over the nerve. This operation has been successful in all the recorded cases.

DISEASES OF NERVES.

Traumatic Neuritis.—This consists in an overgrowth of the connective-tissue framework of a nerve, which causes irritation and pressure upon the nerve fibres, sometimes resulting in their degeneration, and which tends to ascend towards the spinal cord. It may originate in connection with the involvement of a nerve in a scar, or as a result of comparatively slight injuries, such as contusion and compression of a nerve—for example, by the pressure of the head of the humerus in a dislocation of the shoulder. Some weeks or months after the injury the patient complains of increasing hyperæsthesia and of neuralgic pains in the course of the nerve. The nerve is very sensitive to pressure, and, if superficial, may be felt to be swollen. The associated muscles are wasted and weak, and are subject to convulsive twitchings. There are also trophic disturbances. It is rare to have complete sensory and motor paralysis. The disease is commonest in the nerves of the upper extremity, and the hand is often crippled and useless.

Treatment.—Any constitutional condition which predisposes to neuritis, such as gout or syphilis, must receive appropriate treatment. The symptoms may be relieved by rest and by soothing applications such as belladonna or menthol, by the use of hot air and electric baths, and in obstinate cases by blistering or by the application of Corrigan's button. When such treatment fails the nerve may be stretched, or in the case of a purely sensory trunk a portion may be excised. Local causes such as involvement of the nerve in a scar or in adhesions may afford indications for operative treatment.

Multiple Peripheral Neuritis.—Although this disease mainly comes under the cognisance of the physician, it may be attended with phenomena which call for surgical interference.

It may result from a number of causes, acting alone or in combination. In this country it is most commonly due to alcoholism, but it may result from chronic poisoning with lead or arsenic, or from bacterial infections and intoxications such as occur in diphtheria, gonorrhœa, syphilis, leprosy, typhoid, influenza, beri-beri, and many other diseases.

It is usually widely and symmetrically distributed throughout the peripheral nerves, but the distribution frequently varies with the cause the alcoholic form, for example, mainly affecting the legs, the diphtheric form the soft palate and pharynx, and that associated with lead-poisoning chiefly the arms. The essential lesion is a degeneration of the conducting fibres of the affected nerves, and the prominent symptoms are the result of this. The sensory phenomena include numbness and tingling, especially in the fingers and toes, and pain and tenderness along the nerves; complete anæsthesia is rare. The motor phenomena include weakness or actual paralysis of muscles, with wasting, loss of the tendon reflexes, and, in advanced cases, the reaction of degeneration. In alcoholic neuritis there is great tenderness of the muscles. When the legs are affected the patient may be unable to walk, and the toes may droop and the heel be drawn up, resulting in one variety of pes equino-varus. Pressure sores and perforating ulcers are the most important trophic phenomena.

Apart from the medical *treatment*—which includes the use of remedies directed towards the cause of the neuritis, and for the relief of pain—measures must be taken to prevent deformity, especially when the legs are affected. The bed-clothes are supported by a cage, and the feet maintained at right angles to the legs by sand-bags or splints. When the disease is subsiding the nutrition of the damaged nerves and muscles should be maintained by massage, baths, passive movements, and the use of the galvanic current.

NEUROMATA.

Neuroma is a clinical term applied to all tumours, irrespective of their structure, which have their seat in nerves.

Tumours which are composed of newly formed nerve tissue are spoken of as *true neuromata;* when ganglionic cells are present in addition to nerve fibres, the name *ganglionic neuromata* is applied. These tumours are very rare, and are chiefly met with in the main cords or abdominal plexuses of the sympathetic system of children or young adults. They may be solitary or multiple, circumscribed or diffused, and they are quite insensitive. Being usually innocent, their removal is only called for if they cause inconvenience.

The false neuromata are merely connective-tissue overgrowths of the sheaths of nerves. This overgrowth may result in the formation of a circumscribed tumour, or may take the form of a diffuse neuro-fibromatosis.

The circumscribed or solitary tumours grow from the sheaths of nerves which are otherwise healthy, and they may be innocent or malignant.

The innocent forms are usually fibrous or myxomatous, and are definitely encapsulated. They may become cystic as a result of hæmorrhage or of myxomatous degeneration. They grow very slowly, they are usually elliptical in shape, and the solid forms are rarely larger than a hazel nut. The nerve fibres may be spread out all round the tumour, or may run only on one side of it. When subcutaneous and related to the smaller unnamed cutaneous nerves they are known as *painful subcutaneous nodules.* These are chiefly met with in the lower extremities, and especially in women. They are remarkably sensitive, even gentle handling causing intense pain, which usually radiates to the periphery of the nerve affected. When related to deeper, named nerves trunks they are known as *trunk neuromata.* These are usually less sensitive than the "subcutaneous nodule," and they rarely give rise to motor symptoms unless when involving the nerve roots within the spinal canal. Clinically the origin of these swellings from nerves is recognised by their position in the line of a nerve, by the fact that they are movable in the transverse axis of the nerve but not in its long axis, and by their being painful and sensitive.

Treatment.—If they cause much suffering they should be removed, preferably by shelling them out from the investing nerve sheath or capsule. If the nerve is damaged the portion to which the tumour is attached should be resected and the ends sutured. In the subcutaneous nodule the nerve is rarely recognisable, and is usually sacrificed.

The malignant neuroma is really a sarcoma growing from the sheath of a nerve. It has the same characters and clinical features as the innocent neuroma, only it grows more rapidly, and by destroying the nerve fibres it causes motor symptoms—jerkings followed by paralysis. The sarcoma tends to spread along the lymphatic spaces of the affected nerve trunks, as well as to implicate the surrounding tissues, and is liable to give rise to secondary growths. The malignant neuroma is chiefly met with in the great sciatic and other large nerves of the limbs.

The best *treatment* is to amputate the limb well above the growth, as mere removal of the tumour is usually followed by recurrence. In hopeless cases it may be possible to relieve pain by excising a portion of the nerve above the tumour, or, where this is impracticable, by resecting the posterior nerve roots and their ganglia within the spinal canal.

The so-called *amputation neuromata* have already been referred to.

Diffuse or Generalised Neuro-Fibromatosis—Elephantiasis Nervorum.—These terms are now used to include what were formerly known as "multiple neuromata," as well as certain other overgrowths related to nerves. The essential lesion is a diffuse or a generalised overgrowth of the endoneural connective tissue throughout the nerves of both the cerebro-spinal and sympathetic systems. The nerves are diffusely and unequally thickened, so that small twigs may become enlarged to the size of the median, while at irregular intervals along their course the connective-tissue overgrowth is exaggerated so as to form tumour-like swellings very similar to the trunk neuromata already described. The tumours, which vary greatly in size and number,—as many as a thousand or more having been counted in one case,—are enclosed in a capsule derived from the nerve sheath. The fibromatosis may also affect the cranial nerves, the ganglia on the posterior nerve roots, the nerves within the spinal canal, and the sympathetic nerves and ganglia, as well as the continuations of the motor nerves within the muscles. The nerve fibres, although mechanically displaced and dissociated by the overgrown endoneurium, usually undergo no structural change.

The disease probably originates before birth, although it may not make its appearance till adolescence or even adult life. It is sometimes met with in several members of one family. It is recognised clinically by the presence of multiple tumours in the course of the nerves, and sometimes by palpable enlargement of the superficial nerve trunks (Fig. 57). The tumours closely resemble the solitary trunk neuromata, and they often remain quite insensitive. As a result of injury or other exciting cause, however, one or other tumour may increase in size and become extremely sensitive. The pain is much increased by handling, and may interfere with sleep. Motor disturbances are exceptional, unless in the case of tumours within the spinal canal, which sometimes cause paraplegia. Neuro-fibromatosis is frequently accompanied by pigmentation of the skin in the form of brown spots or patches.

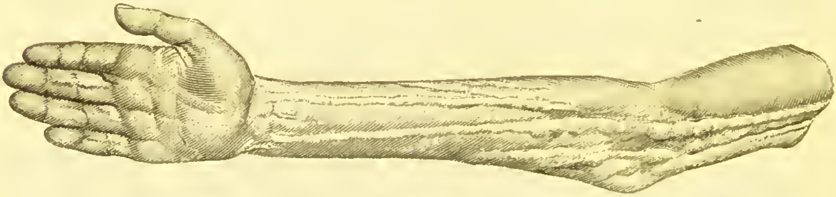

Fig. 57.—Diffuse Enlargement of Nerves in generalised Neuro-Fibromatosis.

(After R. W. Smith.)

The disease is often stationary for long periods. In progressive cases the patient becomes exhausted, and usually dies of some intercurrent affection such as phthisis. The treatment is restricted to relieving symptoms and complications.

In a considerable proportion of cases one or other of the multiple tumours takes on the characters of a malignant growth ("secondary malignant neuroma," Garré). This malignant transformation may follow upon injury, or on the incomplete removal of the tumour. The features are those of a rapidly growing sarcoma involving a nerve trunk, with agonising pain and muscular cramps, followed by paralysis from destruction of the nerve fibres. The removal of the tumour is usually followed by recurrence both in the nerve affected and in other nerves, so that high amputation is the only treatment to be recommended. Metastasis to internal organs is exceptional.

There are certain special types of neuro-fibromatosis which require brief mention.

The plexiform neuroma is a fibromatosis confined to the distribution of one or more contiguous nerves or of a plexus of nerves, and it may occur either by itself or along with a generalised neuro-fibromatosis. The clinical features are those of an ill-defined swelling composed of a number of tortuous, convoluted cords, lying in a loose areolar tissue and freely movable on one another. It is rarely the seat of pain or tenderness. It most often appears in the early years of life, sometimes in relation to a pigmented or hairy mole. It is usually subcutaneous, and is frequently situated on the head or neck in the distribution of the trigeminal or superficial cervical nerves. The results of excision are satisfactory, even if the removal be not quite complete.

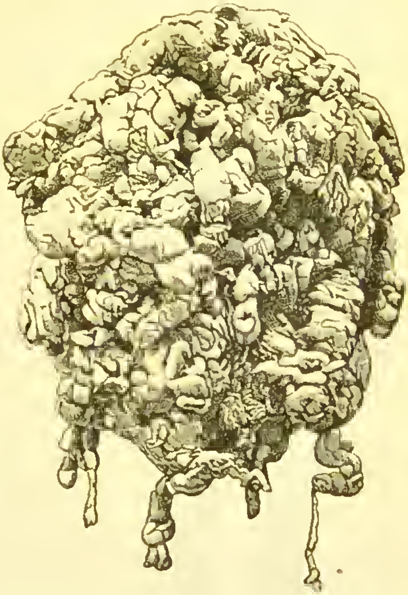

Fig. 58.—Plexiform Neuroma of small Sciatic Nerve, from a girl aged 16.

(Mr. Annandale's case.)

The cutaneous neuro-fibroma or molluscum fibrosum has been shown by Von Recklinghausen to be a soft fibroma related to the terminal filaments of the cutaneous nerves (Fig. 59). The disease appears in the form of multiple, soft, projecting tumours of the skin which are scattered over the body,—except on the palms of the hands and soles of the feet,—and are frequently associated with pigmentation of the skin and with multiple tumours of the nerve trunks. In exceptional cases one of the skin tumours may attain an enormous size and cause a hideous deformity, hanging down by its own weight in lobulated or folded masses (pachydermatocele). They are very closely related to the plexiform neuroma, and the skin over them may be pigmented and hairy. The treatment consists in the removal of the larger swellings, but the small multiple tumours rarely call for interference.

Elephantiasis neuromatosa is the name applied by Virchow to a condition in which a limb is swollen and misshapen as a result of the extension of a neuro-fibromatosis to the skin and cellular tissue of the extremity as a whole. While it resembles other forms of elephantiasis, it usually begins in early life without apparent cause, and it may be associated with multiple tumours of the nerve trunks. The inconvenience caused by the bulk and weight of the limb may justify its removal by amputation.

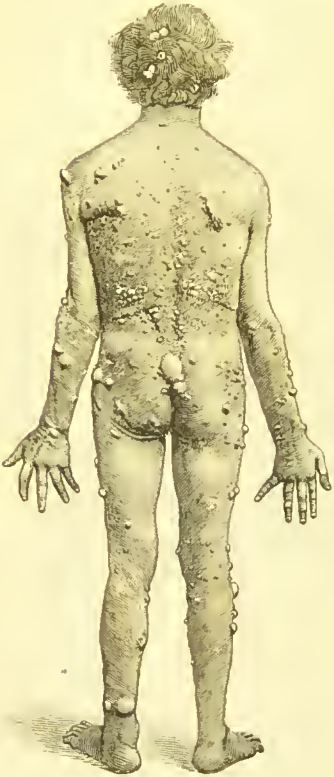

FIG. 59.—Multiple Neuro-Fibromata of Skin (Molluscum fibrosum).

(After Von Recklinghausen.)

SURGERY OF THE INDIVIDUAL NERVES.

The brachial plexus may be contused by the wheel of a cart striking the root of the neck, by displacement of the fragments in a fracture of the clavicle, or by forcible abduction of the arm during anæsthesia, the cords being compressed between the clavicle and first rib. The cords may be torn from their origin by violent traction of the arm upwards and backwards—as by clutching an object when falling from a height.

The symptoms vary with the nature and extent of the lesion. When all the cords are ruptured, the arm hangs powerless by the side, and is anæsthetic save over the upper deltoid region. If the first dorsal root is torn close to its point of emergence from the intervertebral foramen, there is paralysis of the sympathetic fibres to the eye and orbit, with narrowing of the palpebral fissure and recession of the globe, and the pupil is slow to dilate when shaded from the light. The usual trophic changes supervene in the arm, and the humerus is displaced downwards by the weight of the limb.

In partial lesions the fifth and sixth cervical roots most often suffer. They are liable to be stretched as a result of the individual landing on the shoulder, while the head on touching the ground is forced in the opposite direction, so that a considerable stretching force is exerted along the line of the affected nerves (Victor Horsley). There is anæsthesia on the outer aspect of the arm and forearm, paralysis of the deltoid, biceps, brachialis anticus, and supinator longus and brevis muscles (Erb's group of muscles), and pain in the neck and down the arm.

The prognosis varies with the nature of the lesion. When the roots are torn from the cord it is very unfavourable. The patient requires a support for the elbow, or it may be advantageous to bring about ankylosis of this joint in the flexed position, because of the paralysis of its flexors. Where the nerve cords are ruptured the question of uniting them by operation arises. Satisfactory results have been obtained from suture of the cords (Thorburn).

In the birth palsies of the upper extremity in children—first described by Duchenne—the fifth and sixth cervical cords are those usually affected. There is often a history of considerable force having been employed during the birth of the child whereby the nerve cords are bruised or stretched. If there is no prospect of spontaneous recovery as indicated by the development of electrical reactions in the affected muscles, the nerve trunks may be exposed above the clavicle; according to the conditions met with they are freed from adhesions, or, if necessary, resected and sutured (Robert Kennedy).

When the brachial cords are compressed by a cervical rib, a tumour, or a subclavian aneurysm, there is pain and motor weakness in the arm, which are treated by the removal of the compressing cause where this is possible.

The nerve of Bell, which supplies the serratus magnus, may be contused or stretched as a result of injuries to the shoulder, by carrying heavy weights on the shoulder, or from prolonged exertion with the arm raised. The serratus being paralysed, the patient complains of diminished power of elevating the arm above the shoulder, and on examination the vertebral border of the scapula is found to project from the thorax, especially when the arms are stretched out in front (Fig. 259). The arm must be rested and supported in a sling so adjusted as slightly to raise the shoulder, and the functions of the nerve and muscle are promoted by massage and electricity.

The supra-scapular nerve may be paralysed as a result of injuries to the shoulder. The supra- and infra-spinatus muscles are paralysed and wasted, the spine of the scapula becomes unduly prominent, and there is some impairment in the power of raising the arm, and of the finer movements in writing or sewing (Thorburn).

The circumflex nerve is frequently damaged in injuries in the region of the shoulder. The deltoid muscle is paralysed and wastes rapidly, and the arm cannot be raised to the horizontal position. The *sub-scapular nerves* may be injured at the same time, leading to paralysis of the muscles supplied by them. Bilateral paralysis of the deltoid has followed sleeping with the arms raised and the hands clasped behind the head.

Musculo-Spiral Nerve.—In virtue of its anatomical relationships this trunk is more exposed to injury than any other nerve in the body. It is frequently compressed against the humerus in sleeping with the arm resting on the back of a chair, especially in the deep sleep of alcoholic intoxication (drunkard's palsy). It may be pressed upon by a crutch in the axilla, by the dislocated head of the humerus, and by violent squeezing of the upper arm, as when an elastic tourniquet is applied too tightly. The most serious and permanent injuries of the nerve are associated with fractures of the humerus, especially those from direct violence attended with comminution. The nerve may be crushed or torn by one of the fragments at the time of the injury, or at a later period may be compressed by callus.

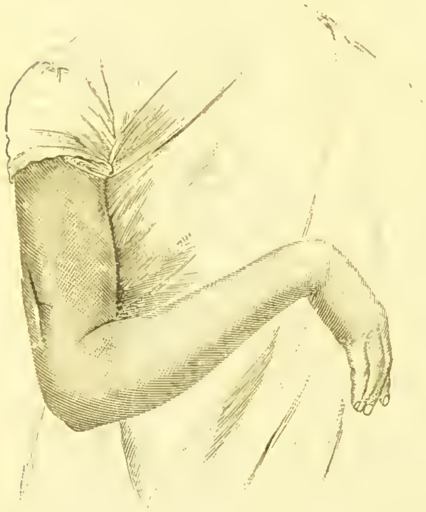

FIG. 60.—Drop-Wrist from Musculo-Spiral Paralysis, the result of wound of upper arm.

Clinical Features.—It is impossible to tell clinically whether the nerve is torn across or merely compressed. The patient often complains of numbness and of tingling in the distribution of the radial nerve, but anæsthesia is usually slight or absent, which may be explained by the fact that the radial side of the hand is occasionally innervated by the median nerve (Kennedy).

The motor symptoms predominate, the muscles affected being the extensors of the wrist and fingers, and the supinators. If the lesion is high up, as it is, for example, in crutch paralysis, the triceps and anconeus may also suffer. There is a characteristic "drop-wrist"; the wrist is flexed and pronated, and the patient is unable to dorsiflex the wrist or fingers (Fig. 60). If the hand and proximal phalanges are supported, the second and third phalanges may be partially extended by the interossei and lumbricals. There is also considerable impairment of power in the muscles which antagonise those that are paralysed, so that the grasp of the hand is very feeble, and the patient almost loses the use of it.

Treatment.—The slighter forms of injury by compression recover under massage, douching, and electricity. In the more severe forms associated with fracture of the humerus, and attended with the reaction of degeneration, it is necessary to cut down upon the nerve and free it from the pressure of a fragment of bone or from callus or adhesions. If the nerve is torn across, the ends must be sutured, and if there is a wide gap between them it may be necessary to resect a portion of the humerus to obtain apposition. If the central end cannot be found or if the gap is very great, the peripheral end may be grafted into the median nerve.

Finally, in cases where the paralysis is permanent and incurable, the disability may be relieved by the transplantation of tendons. The healthy flexor carpi ulnaris is divided, its central end drawn underneath the extensor of the same name, and grafted into the common extensor of the fingers. Similarly the flexor carpi radialis may be divided and drawn beneath the first two extensors of the thumb, and grafted into the tendon of the extensor longus pollicis. After this procedure the patient may recover the use of the thumb and fingers. The extensors of the wrist may be shortened, so as to place the hand in the position of dorsal flexion, and thus improve the attitude and grasp of the hand.

The radial nerve suffers in lesions of the musculo spiral of which it is a branch, and is itself liable to be divided in cuts about the wrist. It is purely sensory in function, and is distributed to that portion of the back of the hand and fingers lying to the radial side of the middle line of the ring finger, with the exception of the terminal portion of these digits which are supplied by the median nerve.

The median nerve may be contused, compressed, or divided in the upper arm or at the bend of the elbow. It is, however, more frequently divided in wounds immediately above the wrist. In the forearm it supplies the pronators, the flexors of the wrist and fingers (excepting the flexor carpi ulnaris and the ulnar half of the flexor profundus), and the flexor longus pollicis. In the hand it supplies the opponens, the abductor and the outer head of the short flexor of the thumb, and the two radial lumbricals, so that wherever the nerve is injured these muscles are apt to be affected. The thumb remains in an extended and abducted position and cannot be opposed to the tips of the fingers, and there is wasting of the ball of the thumb. In those cases in which the nerve is injured above the origin of the branches to the muscles in the forearm, the hand cannot be pronated, and the wrist cannot be flexed except to the ulnar side. The patient is unable to flex the second phalanges on the first or to flex the distal phalanx of the index and middle fingers. He can, however, flex at the knuckles by the action of the interossei. The extent of the anæsthesia is variable; it may or may not correspond to the normal distribution of the nerve to the radial side of the palm, the palmar aspect of the radial three and a half fingers, and the dorsal aspect of the last phalanx of the same fingers. The skin of the finger tips and the nails may suffer from trophic changes (Fig. 13).

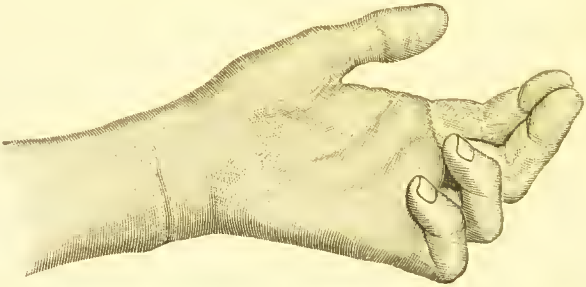

FIG. 61.—Claw-hand following Division of Ulnar Nerve above Wrist.

The Ulnar Nerve.—The most common injury of this nerve is its division in accidental wounds just above the wrist. In the upper arm it may be contused, along with the musculo-spiral, in crutch paralysis. In the groove behind the elbow it may be contused by a blow, or compressed or torn in fractures of the internal condyle of the humerus, or it may be divided in excising the joint.

In the forearm it supplies the flexor carpi ulnaris and the ulnar half of the flexor profundus digitorum; and in the hand, the short muscles of the little finger, the interossei, the two ulnar lumbricals, the adductor, and inner head of the flexor brevis pollicis.

When divided just above the wrist, owing to the resulting paralysis of the interossei and inner lumbricals, the fingers cannot be flexed at the metacarpo-phalangeal joints or extended at the inter-phalangeal joints, the disability chiefly affecting the ring and little fingers. The fingers can neither be adducted nor abducted, and the interosseous spaces are hollowed out from wasting of the interossei. There is loss of adduction of the thumb, and of abduction of the little finger, which can no longer be opposed to the thumb. There is wasting of the hypothenar, and of the ulnar portion of the thenar eminence. In time the contraction of the opponents of the paralysed interossei produces over-extension of the first phalanges and flexion of the others, so that a "claw hand" or *main en griffe* develops, the claw attitude chiefly affecting the ring and little fingers (Fig. 61). The skin and nails of the ring and little fingers often present trophic changes.

When the nerve is injured above the origin of the branches to the muscles in the forearm, the hand when flexed deviates to the radial side, and in time this deviation becomes permanent, and the grasp of the hand is weakened, especially in the ring and little fingers.

The extent of anæsthesia is variable. When the nerve is divided above the origin of the palmar cutaneous branch, the palmar aspect of the ulnar side of the wrist and hand is anæsthetic, as well as the dorsum of the hand and both aspects of the little and of one half of the ring finger.

The external popliteal nerve is most exposed to injury where it winds round the neck of the fibula. It may be compressed by a tight bandage or tourniquet, or it may be bruised or torn in fractures of the upper end of the bone. It has been divided in accidental wounds—by a scythe, for example—and in performing subcutaneous tenotomy of the biceps tendon. Cases have been observed of paralysis of the nerve as a result of prolonged acute flexion of the knee in certain occupations.

When the nerve is paralysed the most obvious result is "drop-foot." The patient is unable to dorsiflex the foot and cannot lift his toes off the ground, so that in walking he is obliged to throw or jerk the foot forwards and outwards. Anæsthesia is absent or very limited. In course of time the foot becomes markedly inverted and the toes are pointed—pes equino-varus—and trophic sores are liable to form.

The internal popliteal nerve, from its anatomical situation, is but rarely injured.

The sciatic nerve also is little exposed to injury. When it is compressed, as by sitting on a fence, there is tingling and powerlessness in the limb as a whole, but these phenomena are usually evanescent. This is commonly known as sleeping of the limb. The most important surgical lesion of the nerve trunk is when a portion of it has been resected in removing a tumour. Although the limb is at first quite powerless, the patient usually recovers sufficiently to be able to walk without a support. The chief clinical feature is "drop-foot." Although the hamstrings are paralysed, the knee can still be flexed by the sartorius and gracilis. The foot is usually cold and bluish, and may present trophic sores. The skin is anæsthetic except in the distribution of the long saphenous nerve.

The anterior crural and obturator nerves are so rarely injured that they do not merit separate consideration.

NEURALGIA.

The term neuralgia is applied clinically to any pain which follows the course of a particular nerve and its branches, and which is not referable to any definite lesion of the nerve, or to any other discoverable cause. This term should not be applied to pain which results from pressure on a nerve by a tumour, a mass of callus, an aneurysm, or by any similar gross lesion. We shall only consider here those forms of neuralgia which are amenable to surgical treatment.

Brachial Neuralgia.—One or more of the roots or branches of the brachial plexus may be the seat of pain which is due to a localised neuritis. In some cases no cause of the neuralgia is discoverable. The region of the root of the neck should be carefully examined to exclude the pressure of a cervical rib, a tumour, or an aneurysm as a cause of the pain. The pain is definitely located in the distribution of one of the branches or nerve roots, is often intermittent, and is usually associated with tingling and disturbance of tactile sensation. When medical treatment fails, recourse may be had to operative measures. The affected cords are exposed and stretched in the posterior triangle of the neck through an incision extending from the outer border of the sterno-mastoid, commencing at the junction of its middle and lower thirds, passing outwards and downwards to the junction of the outer and middle thirds of the clavicle. If this operation fails to give relief, the posterior roots of the nerves may be resected within the spinal canal.

Neuralgia of the great sciatic nerve—**sciatica**—is the most common form of neuralgia met with in surgical practice.

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A definite cause of the pain is rarely ascertainable. The condition is chiefly met with in adults of gouty or rheumatic tendencies who suffer from indigestion, constipation, and oxaluria —in fact, in the same type of patients who are liable to lumbago; and the two affections are frequently associated in the same individual. In hospital practice it is commonly met with in coal-miners and others who assume a squatting position at work. The actual onset of the pain may follow exposure to cold and wet, especially in those who do not take regular exercise. Any error of diet or excessive indulgence in beer or wine may contribute to its development.

The essential symptom is pain along the course of the nerve in the buttock, thigh, and leg. It may be comparatively slight, or may be so severe as to prevent sleep. It is usually aggravated by movement, so that the patient walks lame or is obliged to lie up. It is aggravated, also, by any movement which tends to put the nerve on the stretch, as in bending down to put on the shoes, such movements also causing tingling down the nerve, and sometimes numbness in the foot. This may be demonstrated by flexing the thigh on the abdomen with the knee extended. There is no pain if the same manœuvre is repeated with the knee flexed. The nerve is sensitive to pressure, the most tender points being its emergence from the sacro-sciatic foramen, the hollow between the trochanter and the ischial tuberosity, and where the external popliteal nerve winds round the neck of the fibula. The muscles of the thigh are often weak and wasted.

The clinical features vary a good deal in different cases, but the affection is often very obstinate, and may last for many weeks or even months.

Diagnosis.—Pain referred along the course of the sciatic nerve is a common symptom of tumours of the uterus, the rectum, or the pelvic bones. It may also result from the pressure of an abscess or an aneurysm either inside the pelvis or in the buttock, and is sometimes associated with organic disease of the spinal cord, such as tabes. Sciatica may also be mistaken for disease in the hip or sacro-iliac joints, especially tuberculous disease and arthritis deformans. It is necessary, therefore, to exclude such conditions before arriving at a diagnosis of sciatica. A digital examination of the rectum or vagina is often of great value in excluding intra-pelvic tumours.

Treatment is both general and local. Any constitutional tendency, such as gout or rheumatism, must be counteracted, and indigestion, oxaluria, and constipation must receive appropriate treatment. When the pain is severe the patient is confined to bed and treated by internal remedies, and by external applications, such as fly-blisters or belladonna liniment. In the less severe cases the patient should be encouraged to move about and take regular exercise. Great benefit usually results from bathing, douching, and massage, and from repeated gentle stretching of the nerve. This may be carried out by passive movements of the limb—the hip being flexed while the knee is kept extended; and by active movements—the patient flexing the limb at the hip while the leg is extended on the thigh. These exercises, which may be preceded by massage, are practised night and morning, and should be practised systematically by those who are liable to sciatica.

In obstinate and severe cases *the nerve may be needled*, or it may be *forcibly stretched*. Needling or acupuncture of the sciatic consists in piercing the nerve at intervals in the buttock and down the back of the thigh with long steel needles. Six or eight needles may be inserted and left in position for from fifteen to thirty minutes. The nerve may be stretched under anæsthesia by placing the patient on his back with the hip flexed to a right angle, and then gradually extending the knee until it is in a straight line with the thigh (Billroth). A more effectual method is to expose the nerve through an incision at the fold of the buttock, and forcibly pull upon it. Crawford Renton has pointed out that this operation is most successful when the nerve is involved in adhesions. The general regimen already described is also carried out during the after treatment.

Trigeminal Neuralgia.—A severe form of epileptiform neuralgia occurs in one or more branches of the fifth nerve, and is one of the most painful affections with which we have to deal. So far as its pathology is known, it is believed to be of the nature of a neuritis associated with degenerative changes in the Gasserian ganglion. It is met with in adults and develops without apparent cause; it is fortunately very rare. The pain, which occurs in paroxysms, is at first of moderate severity, but gradually becomes agonising. In the early stages the paroxysms occur at wide intervals, but later they recur with such frequency as to be almost continuous. They are usually excited by some trivial cause, such as opening the jaws in eating or speaking, touching the face as in washing, or by exposure to a draught of cold air. Between the paroxysms the patient is free from pain, but is in constant terror of its return, and the face wears an expression of extreme suffering and anxiety. When the paroxysm is accompanied by twitching of the facial muscles it is called *spasmodic tic.*

The skin of the affected area may be glazed and red, or may be pale and moist with inspissated sweat, the patient not daring to touch it.

There is excessive tenderness at the points of emergence of the different branches of the fifth nerve on the face, and pressure over one or other of these points may excite a paroxysm of pain. The affection is but little amenable to the remedies employed in the treatment of other forms of neuralgia, and is only relieved, as a rule, by large doses of morphin or chloral. In typical cases the patient is unable to take any active part in life. The attempt to eat is attended with such severe pain that he avoids taking food, and he only obtains sleep by the use of hypnotics. In some cases the suffering is so great that the patient is often on the verge of suicide.

Diagnosis.—There is seldom any difficulty in recognising the disease. It is important, however, to exclude the hysterical form of neuralgia, which is characterised by its occurrence earlier in life, by the pain varying in situation, being frequently bilateral, and being more often constant than paroxysmal.

Treatment.—Before having recourse to the measures described below, it is necessary to give a thorough trial to such drugs as arsenic, quinine, and strychnine, and to employ the other medical measures used in the treatment of neuralgia.

The Injection of Osmic Acid into the Nerve.—Although the results of this procedure are uncertain, it may be had recourse to when operative interference is contra-indicated. Five to ten minims of a 1 per cent. solution are injected into the nerve and its vicinity by means of an ordinary hypodermic syringe. The injection is immediately followed by very severe pain, redness, and swelling, but after this subsides there may be no return of the neuralgia.

Operative Treatment.—This consists in the removal of the affected nerve or nerves as completely as possible, either by resection of the nerve—*neurectomy;* or by a combination of resection with twisting or tearing of the nerve from its central connections—*avulsion.* These procedures are fairly successful when the pain is limited to one or more branches of one of the main divisions of the fifth nerve.

The *supra-orbital* and *supra-trochlear* branches of the first division may be resected through an incision made in the line of the eyebrow.

The *infra-orbital* continuation of the second division may be resected by an operation in which the incision is made over the infra-orbital foramen and the nerve is traced back along the canal in the floor of the orbit; or the main trunk may be removed at its emergence from the foramen rotundum along with Meckel's ganglion by resecting and temporarily displacing the malar bone.

The *inferior dental* is the branch of the third division most frequently affected. It may be exposed before it enters the bone by trephining the ascending ramus of the lower jaw opposite the last molar tooth, or below, by cutting down on the nerve as it emerges from the mental foramen; the intervening portion is then pulled out from the inferior dental canal. The *lingual nerve* is also exposed lying in front of the inferior dental when the ascending ramus of the lower jaw is trephined. The *auriculo-temporal* branch is exposed by a vertical incision crossing the zygoma immediately in front of the ear. The *entire trunk of the third division* may be exposed at the foramen ovale by an operation in which the zygoma and the masseter muscle are displaced downwards, the temporal muscle and coronoid process upwards, and the lingual and inferior dental branches are then traced upwards until the main trunk is reached at its emergence from the skull.

When the neuralgia involves branches of two or of all three divisions, or where it has recurred after temporary relief following resection of individual branches, the *removal of the Gasserian ganglion*, along with the main trunks of the second and third divisions, should be considered. This is usually carried out by what is known as the Krause-Hartley operation, which consists in making a large opening into the skull in the temporal region, stripping up the dura, and raising the temporo-sphenoidal lobe of the brain from the middle fossa of the skull until the ganglion is exposed lying on the upper aspect of the petrous temporal bone.

The operation is a difficult and serious one, but the results are most gratifying so far as the cure of the neuralgia is concerned. Krause reports twenty-seven cases with three deaths. There is little or no disability from the unilateral paralysis of the muscles of mastication; but on account of the insensitiveness of the cornea, the eye must be carefully protected from irritation, especially during the first month or two after the operation.

In cases in which the removal of the Gasserian ganglion is contra-indicated, it may be worth while to consider the question of *excising the superior ganglion of the cervical sympathetic.* The resulting vasomotor disturbance may lead to the disappearance of the neuralgia, although this result may be delayed for several months, and cannot be relied upon.

CHAPTER XVII.

THE SKIN AND SUBCUTANEOUS TISSUE.

Structure of skin — *Blisters* — *Callosities* — *Corns* — *Chilblains* — *Boils* — *Carbuncle* — *Abscess* — *Veldt sores* — Tuberculosis of skin: *Inoculation tubercle* — *Lupus*: *Varieties* — Elephantiasis: *Varieties* — Sebaceous cysts or wens — Moles — Horns — New growths: *Fibroma*; *Papilloma*; *Adenoma*; *Epithelioma*; *Rodent cancer*; *Melanotic cancer*; *Sarcoma* — AFFECTIONS OF CICATRICES — *Varieties of scars* — *Keloid* — *Tumours* — AFFECTIONS OF NAILS.

Structure of Skin.—The skin is composed of two layers, a superficial cellular layer, the *epidermis*, along with which should be reckoned the modified depressions of epidermis which form hair follicles, sebaceous and sweat glands. The epidermis is differentiated from without inwards into the stratum corneum or horny layer, the stratum lucidum or clear layer, the stratum granulosum, and the rete Malpighii or germinal layer, from which all the others are developed. The deeper layer of the skin, known as the *corium or true skin*, consists of connective tissue, in which ramify the blood-vessels, lymphatics, and nerves. That part of the corium immediately adjoining the epidermis is known as the papillary portion, and contains the terminal loops of the cutaneous blood-vessels and the terminations of the cutaneous nerves. The deeper layer of the true skin is known as the reticular portion, and is largely composed of adipose tissue.

Blisters result from the exudation and accumulation of serous fluid beneath the horny layer of the epidermis. The fluid may be clear, as in the blister of a recent burn, or blood-stained, as in the blisters so commonly seen in relation to severe fractures of the leg. It may become purulent as a result of the entrance of pyogenic organisms, and blisters may be the starting-point of septic lymphangitis, cellulitis, or bubo.

The *treatment* consists in disinfecting the skin, puncturing the blister, and evacuating the contents. When the contents are septic, the separated horny layer must be cut away with scissors in order to allow of the necessary disinfection.

Callosities are prominent, indurated masses of the overgrown horny layer of the epidermis where it has been exposed to prolonged friction and pressure. They occur on the fingers and hand as a result of certain occupations and sports, but are most common under the balls of the toes or heel. A bursa may form beneath the callosity, and if it becomes inflamed may cause considerable suffering.

The *treatment* of callosities on the foot consists in removing pressure by wearing properly fitting boots and in applying a circular pad over the callosity. In addition, after soaking in hot water, the overgrown horny layer may be pared away with a knife, and the part painted once daily with a saturated solution of salicylic acid in flexile collodion.

Corns.—A corn is a localised overgrowth of the horny layer of the epidermis which grows downwards, pressing upon and displacing the sensitive papillæ of the corium. Corns are due to the prolonged friction and pressure of ill-fitting boots, and are chiefly met with on the toes. The central downgrowth or "corn" is usually hard, dry, and white; but it may be sodden from moisture, as in "soft corns" between the toes. A bursa may form beneath the corn, and if inflamed constitutes one form of bunion. When suppuration takes place in relation to a corn, it is very painful and disabling, and may prove the starting-point of lymphangitis. The suffering which attends ordinary corns varies with the weather and climate.

The *treatment* consists in the wearing of properly fitting boots and stockings, and in removing the corn. This is done after the manner of chiropodists by digging out the corn by suitably shaped knives; a more radically curative procedure is to excise, under local anæsthesia, the portion of skin containing the corn and the underlying bursa. The majority of so-called corn solvents consist of a solution of salicylic acid in collodion; if this is painted on daily the epidermis dies and is thus more easily pared away. The unskilful paring of corns on the toes may determine the occurrence of senile gangrene in those who are predisposed to this disease by atheromatous arteries.

Chilblain. — Chilblain or erythema pernio is a vascular disturbance resulting from the alternate action of cold and heat on the distal parts of the body. Chilblains are chiefly met with on the fingers and toes in children and anæmic girls. In the mild forms there is a sensation of burning and itching, the part rapidly becomes swollen, of a dusky-red colour, and the skin tense and shiny. In more severe cases the burning and itching are attended with pain, and the skin becomes of a violet or wine-red colour. There is a third degree, closely approaching frost-bite, in which the skin tends to blister and give way, leaving an indolent raw surface popularly known as a "broken chilblain."

The *treatment* consists in improving the general health and the circulation by brisk open-air exercise, nourishing food, cod-liver oil, and tonics. Woollen stockings and gloves should be worn in cold weather, and sudden changes of temperature avoided. The symptoms may be relieved by ichthyol ointment, glycerin and belladonna, or a mixture of Venice turpentine, castor oil, and collodion applied on lint which is wrapped round the toe. To broken chilblains balsam of Peru or resin ointment spread on muslin should be applied.

Boils, Carbuncles, Abscesses of the Skin. — These result from infection with the staphylococcus aureus, which penetrates the orifices of the ducts of the skin under the influence of friction and pressure. That infection may take place in this way is demonstrated by the well-known experiment of Garré, who produced a crop of pustules and boils on his own forearm by rubbing in a culture of the yellow staphylococcus.

A **Boil** results when the infection is located in a hair follicle or sebaceous gland. A hard, painful, conical swelling rapidly develops, and so long as the skin retains its normal appearance the term "blind boil" is applied. Usually, however, the skin becomes red, and after a time bursts, giving exit to a drop or two of thick pus. After an interval of from six to ten days a soft white slough is discharged, known as the "core" of the boil. This consists of the necrosed hair follicle and sebaceous gland, and when appropriately stained it is seen to swarm with cocci. After the separation of the core the boil heals, leaving a small depressed scar.

Boils are most frequently met with on the back of the neck and on the buttocks, and on other parts where the skin is coarse and thick and is much exposed to friction and pressure. The occurrence of a number or a succession of boils is due to a spread of the original infection, the pus cocci from the original boil infecting adjacent hair follicles. The spread of boils may be unwittingly promoted by the use of a domestic poultice or the wearing of infected underclothing.

While they are frequently met with in debilitated individuals, such as those suffering from diabetes or Bright's disease, they also occur in those who enjoy vigorous health. They only prove dangerous to life when occurring in diabetic subjects. When they occur on the face there is a greater risk of lymphatic and general pyogenic infection. Boils may be differentiated from syphilitic lesions of the skin by their acute onset and progress, and by the absence of other evidence of syphilis; and from the malignant or anthrax pustule by the absence of the central black slough and of the circumstances which usually favour anthrax infection.

Treatment.—The local treatment consists in relieving the pain of the boil and in preventing the occurrence of others. The skin of the affected area should be sterilised as if for an operation.

A blind boil should be covered with Unna's mercury and carbolic plaster, or an ointment containing 20 per cent. oleate of mercury and 5 per cent. carbolic acid should be rubbed into the skin over it. Where boils tend to recur on the back of the neck this ointment should be rubbed into the skin every second night. In boils on the trunk and limbs, lysol or boracic baths are of great service; the underclothing should be frequently changed, and that which is discarded should be disinfected.

In a boil which is going on to suppuration the question of incision arises. As in other suppurative lesions, suffering is relieved and repair is hastened by a timely incision and evacuation of the pus. The core is then removed with the sharp spoon, and the wound swabbed out with pure carbolic acid.

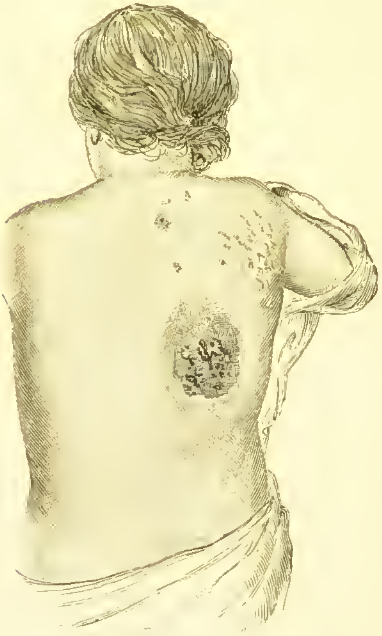

Fig. 62.—Large Carbuncle of Back.

On the other hand, warm carbolic fomentations may be applied until the boil bursts and the core separates. The further treatment consists in the use of diluted boracic or resin ointment. Although constitutional treatment has no direct curative influence on boils, any impaired condition of health should be corrected. When there is sugar or albumin in the urine the conditions on which these depend must receive appropriate treatment.

Carbuncle is a spreading inflammation of the deeper layers of the skin attended with suppuration and sloughing (Fig. 62).

It may be looked upon as a number of boils aggregated together, and it commences like a large boil with a densely hard base and a brownish-red discoloration of the skin. A carbuncle is usually about the size of a crown piece, but it may continue to enlarge until it attains the size of a dinner plate. The patient is decidedly run down, ill, and feverish, and the pain may be so severe as to prevent sleep. As time goes on several points of suppuration appear, and when these burst there result a number of openings in the skin giving it a cribriform appearance: these openings exude pus. The different openings ultimately fuse together and a large adherent greyish-white slough is exposed. The separation of this slough is a tedious process, and the patient may become exhausted by pain, discharge, and septic absorption. When the slough is finally thrown off, a large deep gap is left which takes a long time to heal. A large carbuncle is a grave disease, especially in a weakly individual, and in one suffering from diabetes or chronic alcoholism. In the majority of cases the patient is laid aside for several months. It is most common in male adults over forty years of age, and is usually situated on the back between the shoulders. When it occurs on the face or anterior part of the neck it is especially dangerous, because of the greater risk of general infection and septicæmia.

A carbuncle is to be differentiated from a syphilitic gumma by its more acute progress and its rapidly destructive qualities.

Treatment.—Pain is to be relieved by full doses of opium or codein. Opium is especially indicated where sugar is present in the urine. The diet should be liberal and easily digested, and alcoholic and other stimulants may be of service in tiding the patient over the critical period of the disease. Locally, carbolic fomentations are employed until suppuration commences. If the patient is able to stand an operation, the best procedure is to excise the carbuncle, cutting all round it and down to the deep fascia, swabbing the wound with pure carbolic acid, and packing with gauze. The illness is thereby much shortened, suffering is relieved, and the risk of extension and general infection abolished. When the resulting wound becomes covered with healthy granulations, it may be covered over with Thiersch grafts.

Where excision is contra-indicated, the next best procedure is to make several incisions across the carbuncle in different directions so that the resulting wound presents a stellate appearance; then to cut away the undermined skin, remove the slough, and rub pure carbolic acid into all the exposed tissues, and pack with iodoform gauze or worsted.

In very feeble individuals these operations are inadmissible, and treatment is restricted to applying antiseptic fomentations, unless the pain is unbearable, in which case a simple incision under chloride of ethyl may be made to relieve tension and allow of discharge.

Acute Abscesses of the Skin and Subcutaneous Tissue in Young Children.—In young infants abscesses are not infrequently met with scattered over the trunk and limbs, and are probably the result of infection of the sebaceous glands from dirty underclothing. The abscesses should be opened, and the further spread of infection prevented by thorough cleansing of the skin and by the use of clean under-linen. Similar abscesses are met with on the scalp in association with eczema, impetigo, and pediculosis.

Veldt Sores.—These have become well known owing to their prevalence among the troops during the recent war in South Africa. The sore usually originates in an abrasion of the epidermis, such as a sun blister, the bite of an insect, or a small wound or scratch. A pustule forms and bursts, and a brownish-yellow scab forms over it. When this is removed a raw surface or ulcer is left which has little tendency to heal. These sores are most common about the hands, arms, neck, and feet, and are most apt to occur in those who have had no opportunities of washing, and who have lived for a long period on tinned foods. The appearance of a number of white scars each surrounded by a zone of pigmentation is commonly observed in those who have suffered from veldt sores.

Tuberculosis of the Skin.—Interest chiefly attaches to the primary forms of tuberculosis of the skin in which the bacilli usually penetrate from without.

Inoculation Tubercle.—The appearances vary with the conditions under which the inoculation takes place. As observed on the fingers of adults, the affection takes the form of an indolent, painless swelling, the epidermis being red and glazed or warty and irregularly fissured. Sometimes the epidermis gives way, forming an ulcer with flabby granulations. The infection very rarely spreads to the lymphatics. As it frequently occurs in pathologists and others who handle dead bodies, it is sometimes known as "anatomical tubercle." In children who run about barefooted in towns, tubercle may be inoculated into accidental wounds in the sole or about the toes, and although the local appearances may not be characteristic, the nature of the infection is revealed by its tendency to spread up the limb along the lymphatic vessels, giving rise to enlargement, abscesses, and fungating ulcers in relation to the femoral glands.

The *treatment* consists in excising the infected sore and in covering the resulting raw surface with a Thiersch graft. Where this is impracticable the infected tissues are removed with the sharp spoon.

Tuberculous Lupus.—This is an extremely chronic affection of the skin. It very rarely extends to the lymphatic glands, and of all tuberculous lesions is the least dangerous to life. The commonest form of lupus—*lupus vulgaris*—usually commences in childhood or youth, and is most often met with on the nose or cheek. The early and typical appearance is that of brownish-yellow or pink nodules in the skin, about the size of a hemp seed. The appearance of the contents of these nodules has been likened by Hutchinson to apple jelly. Their characters are best studied by examining them through a lens pressed firmly against the skin. Microscopical examination of the skin shows the apple-jelly material to consist of aggregations of epithelioid and giant cells over which the epidermis is stretched and thinned. Tubercle bacilli are scanty and difficult to stain. The original nodules tend to fuse together, while fresh ones are formed at the margins. "The epidermis, as a result of surface irritation in which pus organisms play a prominent part, becomes the seat of a catarrhal process attended with a discharge of pus which dries up, forming yellowish-brown crusts or scabs, and the apple-jelly nodules are thereby concealed; when the scabs are removed what looks like a raw surface covered with pale granulation tissue is exposed" (Norman Walker). Healing frequently occurs in the centre of the affected area while the disease is extending at the margins.

When there is actual destruction of tissue and ulceration—the so-called "*lupus exedens*" or "*ulcerans*"—healing is attended with cicatricial contraction, which may cause unsightly deformity. When the cheek is affected the lower eyelid may be drawn down and everted; when the lips are affected the mouth may be distorted or seriously diminished in size. When the nose is affected, both the skin and mucous surfaces are usually involved, and the nasal orifices may be narrowed or even obliterated. Sometimes the entire soft parts, including the cartilages, are destroyed, leaving only the bones covered by tightly stretched scar tissue.

The disease progresses very slowly, healing in some places and spreading at others. The patient complains of a burning sensation, but of very little pain, and is chiefly concerned about the disfigurement. Nothing is more characteristic of lupus than the appearance of fresh nodules in parts which have already healed.

In the course of years large tracts of the face and neck may become affected. From the lips it may spread on to the gum and palate, giving to the mucous membrane the appearance of a raised, bright-red, papillary or villous surface. The teeth may become loose and fall out when the disease affects the gums.

On parts of the body other than the face the disease is even more chronic, and is often attended with a considerable production of dense fibrous tissue—the so-called *fibroid lupus;* there are very few tubercle nodules, and the disease has little tendency to spread or to destroy parts. Sometimes it is attended with a warty thickening of the epidermis—*lupus verrucosus.* In the fingers and toes it may be attended with progressive destruction of tissue like that observed in certain forms of leprosy, and from the resulting loss of portions of the digits it has been called *lupus mutilans.* In the lower extremity a remarkable form of the disease is sometimes met with to which the term *lupus elephantiasis* has been applied. It usually commences as an ordinary lupus of the toes or dorsum of the foot, from which the tuberculous infection spreads to the lymphatic vessels, and the limb as a whole becomes enormously swollen and unshapely (Fig. 65).

Finally, a long-standing lupus, especially on the cheek, may become the seat of epithelioma, usually of the exuberant or cauliflower type, which presents little tendency to infect the lymphatics.

The *diagnosis* of lupus is founded on the recognition of the apple-jelly nodules, on the chronic progress and long duration, and the central scarring with peripheral extension of the disease. On the face it is most liable to be confused with syphilis and with rodent cancer. The syphilitic lesion belongs to the tertiary period, and although presenting a superficial resemblance to tuberculosis its progress is much more rapid, so that within a few months it may involve an area of skin as wide as would be affected by lupus in as many years. Further, it readily yields to anti-syphilitic treatment. In the rare cases of tertiary syphilis in which the nose is destroyed it will be noticed that the bones have suffered most, whereas in lupus the destruction of tissue chiefly involves the soft parts of the tip of the nose.

Rodent cancer is very liable to be mistaken for lupus, because it may affect the same parts of the face, it is equally chronic, and may partially heal. It begins later in life, however, the margin of the ulcer is more sharply defined, and often presents a "rolled" appearance (Figs. 67 and 68).

The *treatment* of lupus varies with its situation, its extent, and the stage at which it is met. Although general treatment is called for, in all cases it is rarely curative, and local measures are required to eradicate what is after all a purely local disease.

Numerous methods are employed for the local treatment of lupus, and much difference of opinion exists as to the relative merits of the different methods. When the disease is confined to a very limited area the most rapid and certain cure is obtained by *excision*. The whole thickness of skin is removed throughout and beyond the area affected; the edges of the gap are brought together by sutures, or the raw surface is covered with a Thiersch graft. On the covered parts of the body excision may be employed, even when the disease involves an extensive area.

When lupus covers a wide area of the face, as is so commonly the case in hospital practice, there is great difficulty in bringing about a cure. In recent years the therapeutic effects obtained by exposure to different forms of rays have been employed with so much success in this group of cases that they have superseded the older methods of scraping away the diseased tissue with the sharp spoon, or destroying it with the cautery or with chemical agents. The *ray treatment* includes the use of luminous, Röntgen or other rays, and possesses the advantage of being comparatively painless and of being followed by the least amount of scarring and deformity.

The light treatment, introduced by Finsen of Copenhagen, consists in concentrating sunlight, or, in its absence, the electric arc light, by means of apparatus which cuts off the heat rays, so that the blue, violet, and ultra-violet rays are allowed to act upon the diseased tissue. This is followed by an inflammatory reaction in the adjoining tissues, which results in the destruction of the tubercle bacilli. The disadvantages of the method are the small area which can be subjected to the rays at each exposure, so that the treatment is very prolonged; a large area may require hundreds of exposures.

The Röntgen ray treatment consists in exposing the diseased area to the rays from a Crookes' tube of about six inches spark, for ten to fifteen minutes daily, at a distance of from four to five inches from the tube. The healthy skin is protected by a sheet of lead foil, from which a piece is cut out corresponding to the diseased area. After a variable number of exposures inflammatory reaction takes place, and experience is required to control the effects within the desired limits. The duration of treatment is usually shorter than by the Finsen method.

The rays given off from the recently discovered element, radium, have been found to have a similar curative influence on tuberculous lesions of the skin.

Scrofuloderma, Scrofulous Gummata.—These terms are employed to indicate the development of multiple subcutaneous tuberculous tumours chiefly met with on the extremities of children (Fig. 63). They are indolent and painless, and rarely attract attention until they break down and form abscesses, which are usually about the size of a cherry, and when these burst sinuses or ulcers result. If the overlying skin is still intact the best treatment is to excise the tumours. If the abscess has already infected the skin, each focus should be scraped, swabbed out with pure carbolic acid, and packed with gauze.

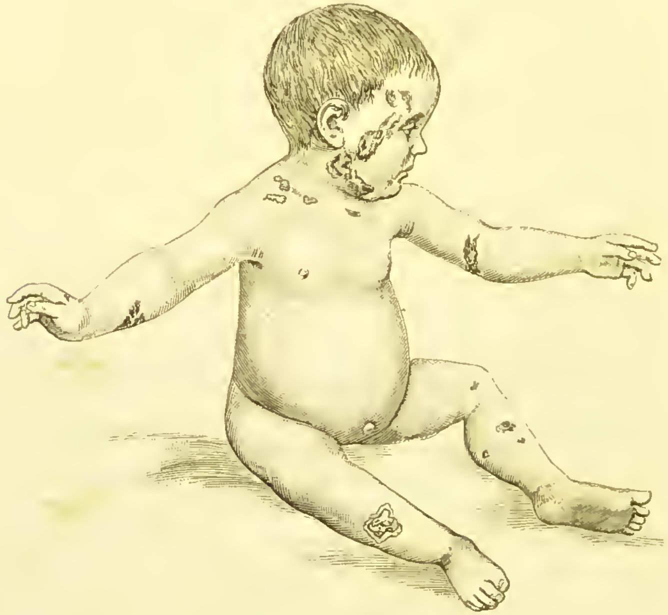

FIG. 63.—Multiple Tuberculous Abscesses of Skin.

The *secondary forms of tuberculosis of the skin* usually result from the rupture of cold abscesses which have originated from tuberculous disease of lymphatic glands, bones or joints. They are most often met with in the neck, in association with disease in the glands, in the form of multiple tuberculous ulcers (Fig. 54).

Elephantiasis.—This term is applied to an excessive enlargement of a part which depends upon a widely spread overgrowth of the skin and subcutaneous cellular tissue. It may result from a number of causes, acting independently or in combination, and is observed chiefly in the extremities and in the external organs of generation.

Elephantiasis from Lymphatic or Venous Obstruction.—Of this the best-known example is *tropical elephantiasis* (E. arabum), which is endemic in Samoa, Barbadoes, and certain other places. It attacks the lower extremity or the external genitals in either sex (Fig. 64). The disease is usually ushered in with fever, and signs of inflammation in the part affected, of the nature of lymphangitis. After a number of such attacks, the lymphatic vessels appear to become obliterated, and the skin and subcutaneous cellular tissue, being bathed in stagnant lymph,—which possibly contains the products of streptococci, take on an overgrowth, which continues until the part assumes gigantic proportions. In a certain number of cases the lymphatic trunks have been found to be blocked with the ova of the filaria sanguinis hominis or with the parent worms. It must be clearly understood, however, that *sporadic cases* of elephantiasis of the lower extremity are met with in this country in which there are no filarial parasites in the lymphatics. These sporadic cases present features indis-

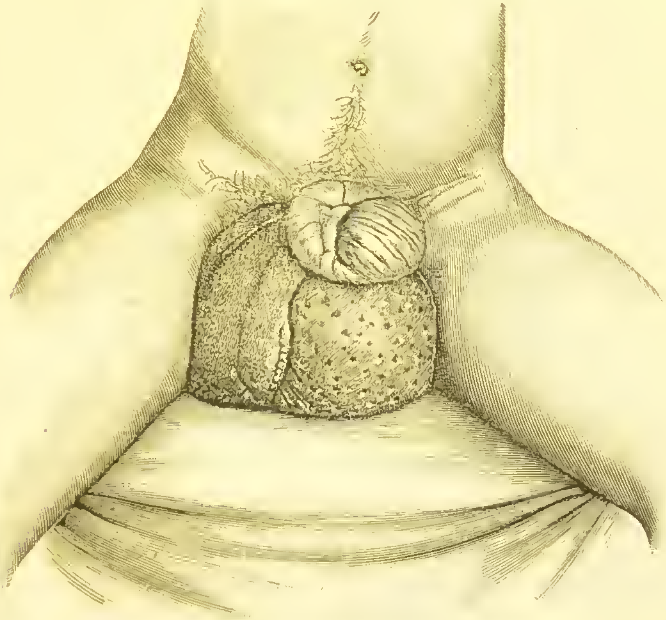

FIG. 64.—Elephantiasis of Penis and Scrotum in native of Demerara.

(Mr. Annandale's case.)

tinguishable from the tropical variety, and usually follow upon repeated attacks of lymphangitis or erysipelas.

The part affected with elephantiasis is enormously increased in size, and causes inconvenience from its bulk and weight. In contrast to ordinary dropsy, there is no pitting on pressure. The skin tends to become rough and warty, and may hang down in pendulous folds. Blebs may form on the surface and yield an abundant exudate of clear lymph. From neglect of cleanliness, the skin may become the seat of eczema or even of ulceration attended with foul discharge.

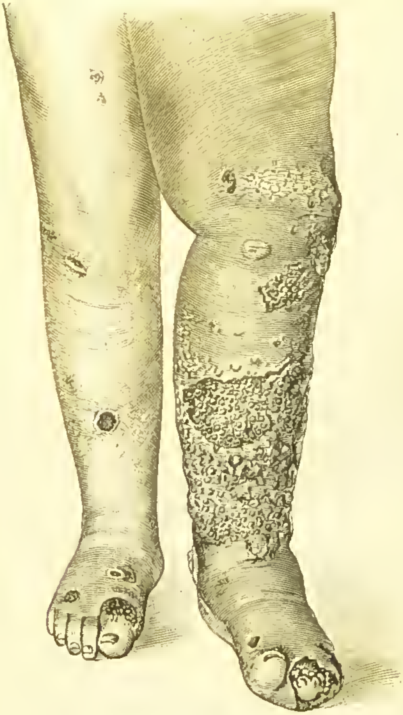

Fig. 65.—Lupus Elephantiasis of Left Lower Extremity.

(Sir P. H. Watson's case.)

The *treatment* consists in maintaining an aseptic condition of the part, combating the inflammatory attacks, and reducing the swelling by elevation of the limb, massage, and the use of an elastic bandage. Removal of the overgrown tissues is commonly practised in elephantiasis of the external genitals, but is rarely indicated in the lower extremity.

A similar type of elephantiasis may occur in the upper or lower extremity after extirpation of all the lymphatic glands in the axilla or groin; in the leg in long-standing varix and phlebitis with chronic ulcer; in the arm as a result of extensive cancerous disease of the lymphatics; in the axilla secondary to cancer of the breast; and in extensive tuberculous disease of the lymphatics. The last-named is chiefly observed in the lower limb in young adult women, and from its following upon lupus of the toes or foot it has been called *lupus elephantiasis* (Fig. 65). The tuberculous infection spreads very slowly up the limb by way of the lymphatics, and as these are obliterated the skin and cellular tissue become hypertrophied, and the surface studded over with fungating tuberculous masses of a livid-blue colour. As the disease may prove dangerous to life by septic complications inducing gangrene of the limb, the question of amputation may have to be considered in advanced cases.

Belonging to this group also is a form of congenital elephantiasis resulting from the circular constriction of a limb *in utero* by amniotic bands.

Elephantiasis occurring apart from lymphatic or venous obstruction is illustrated by *elephantiasis nervorum,* in which there is an overgrowth of the skin and cellular tissue of an entire extremity in association with neuro-fibromatosis of the cutaneous nerves; and by *elephantiasis Græcorum*—a form of leprosy in which the skin of the face becomes the seat of tumour-like masses consisting of leprous nodules. It is also illustrated by *elephantiasis involving the scrotum* as a result of the prolonged irritation of the urine in cases in which the penis has been amputated and the urine has been allowed to infiltrate the scrotal tissues.

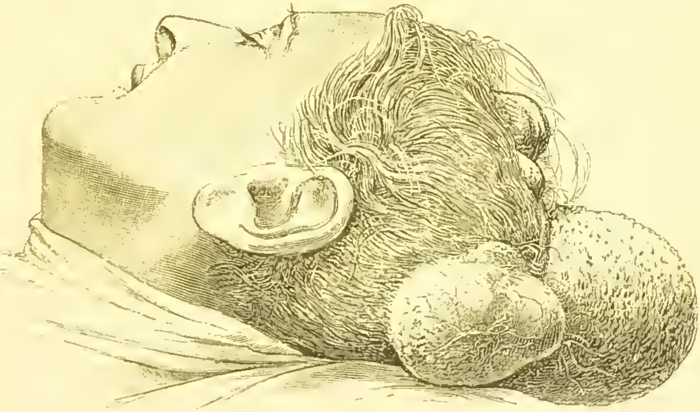

FIG. 66.—Multiple Sebaceous Cysts or Wens.

Sebaceous Cysts.—Atheromatous cysts or wens are retention cysts formed in relation to the sebaceous glands and hair follicles. They are commonly met with in adults, on the scalp (Fig. 66), face, neck, back, and external genitals. Sometimes they are multiple, and they may be met with in several members of the same family. They are smooth, discoid cysts, varying in size from a split pea to a tangerine orange. In consistence they are firm and elastic, or fluctuating, and are incorporated with the overlying skin, but are movable on the deeper structures. The orifice of the partially blocked sebaceous follicle may be visible (except on the scalp), and some of the contents of the cyst can be squeezed through the opening. The wall of the cyst is composed of a connective-tissue capsule lined by stratified squamous epithelium. The contents consist of accumulated epithelial cells, and are at first solid, and pearly white in appearance, but as a result of fatty degeneration they break down into a greyish-yellow pultaceous and semi-fluid material having a peculiar stale odour. It is probable that the decomposition of the cyst contents is the result of the presence of bacteria, and that from the surgical point of view they should be regarded as septic. A sebaceous cyst may remain indefinitely without change, or may slowly increase in size, the skin over it becoming stretched and closely adherent to the cyst wall as a result of friction and pressure. Sometimes the contents ooze from the orifice of the duct and dry on the skin surface, leading to the formation of a sebaceous horn. Sometimes as a result of injury the cyst undergoes sudden enlargement from hæmorrhage into its interior.

Inflammation, which may subside and recur, is a frequent complication, especially in wens of the face and scalp. Suppuration may occur and be followed by cure of the cyst, or, if the contents are imperfectly discharged, the remainder may decompose, and an offensive fungating ulcer which may be mistaken for epithelioma may form. True cancerous transformation is very rare.

Wens are to be *diagnosed* from dermoids, from fatty tumours, and from cold abscesses. Dermoids occur in certain special situations; they usually appear before maturity, and as they nearly always lie beneath the fascia the skin is movable over them. A fatty tumour is more movable, and is often lobulated. The confusion with a cold abscess is most likely to occur in wens of the neck or back, and it may be impossible without operation to differentiate between them.

Treatment.—The removal of wens is to be recommended while they are still small and freely movable, as they are then easily shelled out after incising the overlying skin. In large and adherent wens an ellipse of skin should be removed along with the cyst. When inflamed, the cyst wall must be destroyed with pure carbolic acid, the resulting wound being treated by the open method.

Moles.—The term mole is applied to a pigmented, and usually hairy, patch of the skin present at or appearing shortly after birth. The colour varies from brown to black according to the amount of melanin pigment present. The essential lesion consists in an overgrowth of epidermis continuous with that on the surface, and often presenting an alveolar arrangement.

Moles vary greatly in size: some are mere dots, others are as large as the palm of the hand, and occasionally a mole covers half the face or trunk. In addition to being unsightly, they bleed freely when abraded, are liable to ulcerate from friction and pressure, and are apt to become the starting-point of melanotic cancer. The slightly pigmented moles met with on the face may become the starting-point of rodent cancer. Overgrowths in relation to the cutaneous nerves, especially the plexiform neuroma, occasionally originate in pigmented moles. Soldau believes that the pigmentation and overgrowth of the epidermis in moles are associated with, and probably result from, a fibromatosis of the cutaneous nerves.

Treatment.—The best way to get rid of a mole is to excise it. If the edges of the gap cannot be brought together with sutures, recourse should be had to Thiersch grafting. In large hairy moles of the face whose size forbids excision, the hairs may be got rid of by the Röntgen rays, or by the plan suggested by Victor Horsley, which consists in reflecting a flap of skin including the mole, and shaving away its deep aspect until the hair follicles are removed; after which the flap is replaced and sutured. Although the pigmentation remains there is no further growth of hair.

Horns.—Four varieties of cutaneous horn are described by Bland Sutton. The *sebaceous* horn results from the accumulation of the dried contents of a wen on the surface of the skin. The sebaceous material after drying up becomes cornified, and as fresh material is added to the base the horn increases in length. The *wart* horn grows from a warty papilloma of the skin. *Cicatrix* horns are formed by the heaping up of epidermis in the scars which result from burns. *Nail* horns are overgrown nails (keratomata of the nail bed), and are chiefly met with in the great toe of elderly bed-ridden patients.

A horn may be the starting-point of epithelioma which originates in relation to an ulcer at its base. The horn should be removed with or without the area of skin around its base.

New Growths in the Skin and Subcutaneous Tissue.—*Fibroma.*—Various types of fibroma are met with in the skin. Soft pedunculated fibromata, about the size of a pea, are very commonly met with, especially on the neck and trunk; they are usually solitary, and are of no clinical importance. The multiple soft fibromata, known as *molluscum fibrosum*, which depend upon a neuro-fibromatosis of the cutaneous nerves, are described with the tumours of nerves. Hard fibromata occurring singly or in groups may be met with, especially in the skin of the buttock, and may present a local malignancy, recurring on removal like the "recurrent fibroid" of Paget. The "painful subcutaneous nodule" is a solitary fibroma related to one of the cutaneous nerves. The hard fibroma known as keloid is described with the affections of scars.

Papilloma.—The *common wart* or verruca is an outgrowth of the surface epidermis. It may be sessile or pedunculated, hard or soft. The surface may be smooth, or fissured and foliated like a cauliflower, or it may be divided up into a number of spines. Warts are chiefly met with on the hands and face, and are often multiple, occurring in clusters or in successive crops. Multiple warts appear to result from some contagion, the nature of which is unknown; they sometimes occur in an epidemic form among school children. They show a remarkable tendency to disappear spontaneously. The solitary flat-topped wart which occurs on the face of old people may, if irritated, become the seat of epithelioma.

Treatment.—In the multiple warts of children the health should be braced up by a change to the seaside. A dusting powder, consisting of boracic acid with five per cent. salicylic acid, may be rubbed into the hands after washing and drying. The persistent warts of young adults are best removed with scissors after freezing with chloride of ethyl. When cutting is objected to they should be painted night and morning with salicylic collodion, the epidermis being dehydrated with alcohol before each application.

Venereal warts occur on the genitals of either sex, and may form large cauliflower-like masses on the inner surface of the prepuce or of the labia majora. Although frequently coexisting with gonorrhœa or syphilis, they may occur independently of these diseases, being probably acquired by contact with another individual suffering from warts (C. W. Cathcart). They give rise to considerable irritation and suffering, and when cleanliness is neglected they may be attended with an offensive discharge.

In advanced cases with large cauliflower-like masses it is best to remove them. In the female they are dissected off from the labia; in the male the prepuce is removed and the warts on the glans are snipped off with scissors. In milder cases the warts usually disappear if the parts are kept absolutely dry and clean. A useful dusting-powder is one consisting of calamine and five per cent. salicylic acid. The exsiccated sulphate of iron may be employed in cases which resist this treatment.

Lastly, a warty growth of the epidermis may be an accompaniment of lupus—lupus verrucosus—and of moles.

Adenoma.—This is a comparatively rare innocent tumour growing from the glands of the skin. One variety, known as the "tomato tumour," which apparently originates from *the sweat glands*, is chiefly met with on the scalp and face in women past middle life. These growths are often multiple; the individual tumours vary in size, and the skin, which is almost devoid of hairs, is glistening and tightly stretched over them. A similar tumour may occur on the nose. The *sebaceous adenoma*, which originates from the sebaceous glands, may form a projecting tumour on the scalp like a wen, only it is solid. When the skin is irritated it may ulcerate and fungate. The treatment consists in the removal of the tumour. The exuberant masses on the nose known as "lipoma nasi" or "potato-nose" are of the nature of sebaceous adenomata, and are removed by shaving them off with a knife until the normal shape of the nose is restored. Healing takes place with remarkable rapidity.

Cancer.—There are several types of primary cancer of the skin, the most important being squamous epithelioma, rodent cancer, and melanotic cancer.

Epithelioma occurs in a variety of forms. When originating in a small ulcer or wart—for example, in the skin of the face in old people—it presents the features of a chronic indurated ulcer. A more exuberant and rapidly growing form of epithelial cancer has been described by Hutchinson as the *crateriform ulcer*. This commences on the face as a small red pimple which rapidly develops into an elevated mass shaped like a bee-hive and breaks down in the centre. Epithelioma may develop anywhere on the body in relation to scar tissue, especially that resulting from burns or lupus. This form usually presents an exuberant outgrowth of epidermis not unlike a cauliflower wart. Mention should also be made of the paraffin-worker's, chimney-sweep's, and other forms of what may be called trade epithelioma, and of arsenic cancer occasionally observed in those who have taken large doses of arsenic for medicinal purposes over long periods.

Rodent Cancer (rodent ulcer).—This is a true cancer originating in the sweat glands or sebaceous follicles, or in the fœtal residues of cutaneous glands. The cells are small and closely packed together in alveoli or in reticulated columns. Cell nests are very rare. It is remarkably constant in its seat of origin, being nearly always located on the lateral aspect of the nose or in the vicinity of the lower eyelid (Figs. 67, 68). It is extremely rare on the trunk or limbs. It nearly always commences as a small flattened nodule in the skin, the epidermis over it being stretched and shining. The centre tends to become depressed, while the margin extends in the form of an elevated ridge. Sooner or later ulceration takes place in the centre, and the epidermis gives way, exposing a smooth raw surface devoid of granulations. The margin, while in parts irregular and ill-defined, is typically represented by a well-defined "rolled" border which consists of the peripheral portion of the cancer which has not yet broken down. The central ulcer may temporarily scar over. There is itching but very little pain, and the condition progresses extremely slowly, so that rodent cancers which have existed for many years are frequently met with. It attacks and destroys every structure with which it comes in contact, such as the eyelids, the walls of the nasal cavities, and the bones of the face; hence it may produce the most hideous deformities (Fig. 69). The patient may succumb to hæmorrhage or to septic complications such as erysipelas or meningitis.

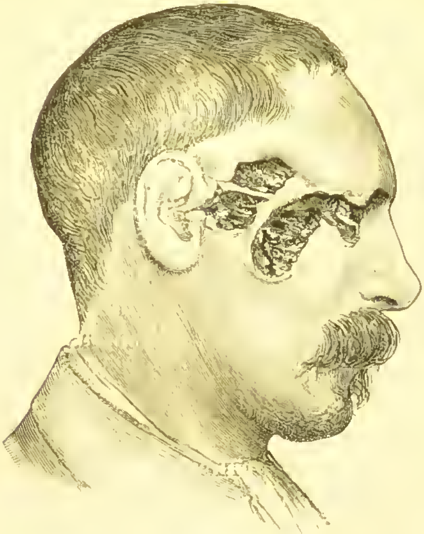

FIG. 67.—Rodent Cancer.
(Mr. Annandale's case.)

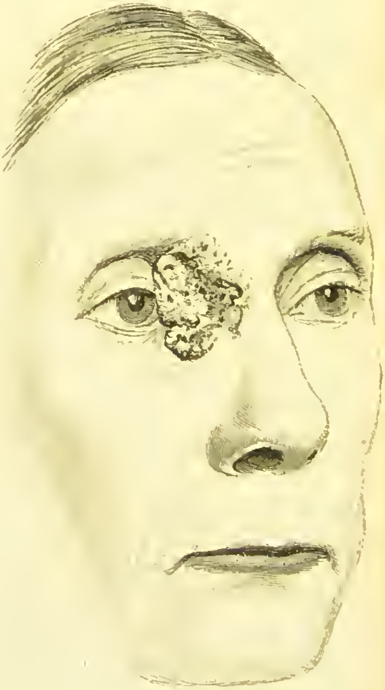

FIG. 68.—Rodent Cancer of Inner Canthus.

Secondary growths in the lymphatic glands, while not unknown, are extremely rare. We have only once seen them—in a case of rodent cancer in the groin.

Diagnosis.—Lupus is the disease most often mistaken for rodent cancer. Lupus usually begins earlier in life, it presents the apple-jelly nodules, and it lacks the rounded, elevated border. Doubtful cases should be treated as rodent cancer. Syphilitic lesions progress more rapidly and also lack the characteristic margin. The differentiation from squamous epithelioma is not as a rule difficult, but is of considerable importance, as the latter affection, from its tendency to spread by the lymphatics, is dangerous to life.

Treatment.—In rodent cancers of limited size—say less than one inch in diameter—free excision is the most rapid and certain method of treatment. The edges of the gap are brought together with sutures, or the raw surface covered with a Thiersch graft. If the patient objects to a cutting operation, the growth is best destroyed by means of a paste of arsenious acid. If the cancer already covers an extensive area of the face, or has invaded the cavity of the orbit or nose, removal of the growth by knife or cautery is unsatisfactory, and recourse should be had to the Röntgen rays. The effect of the Röntgen rays is soon shown by the ingrowth of healthy epithelium from the surrounding skin, so that healing is promoted, and at the same time the pain and discharge are much lessened. Plastic operations—for example, the formation of a new nose—may be required to remedy deformities resulting from the disease.

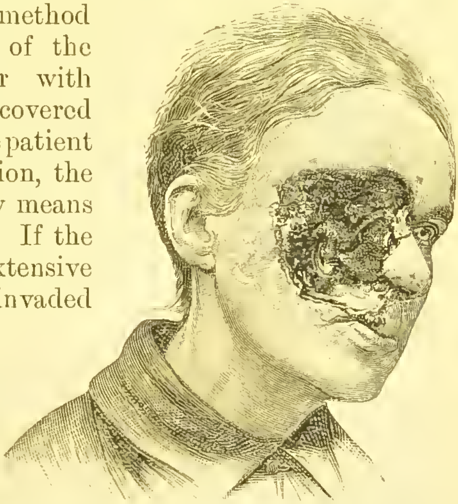

FIG. 69.—Rodent Cancer of fifteen years' duration, which has destroyed contents of Orbit.

(Mr. J. M. Cotterill's case.)

Melanotic Cancer.—Under this head are included all new growths of the skin which contain an excess of melanin pigment. Many of these were formerly described as melanotic sarcoma. They nearly always originate in a pigmented mole which has been subjected to irritation. The primary growth may remain so small that its presence is not even suspected, or it may increase in size, ulcerate, and fungate through the skin. The amount of pigment varies: when small in amount the growth is brown, when abundant it is a deep black. The most remarkable feature is the rapidity with which the disease becomes disseminated along the lymphatics, the first evidence of which is an enlargement of the lymphatic glands. As the primary growth is often situated on the sole of the foot (Fig. 70) or in the matrix of the nail of the great toe, the femoral and inguinal glands become enlarged in succession, forming tumours much larger than the primary growth. Sometimes the dissemination involves the lymphatic vessels of the limb, forming a series of indurated pigmented cords and nodules (Fig. 71). Lastly, the dissemination may be universal throughout the body, and this usually occurs at a comparatively early stage in the disease, although it has been delayed in some cases for several years. The secondary growths are deeply pigmented, being usually of a coal-black colour, and melanin pigment may be present in the urine.

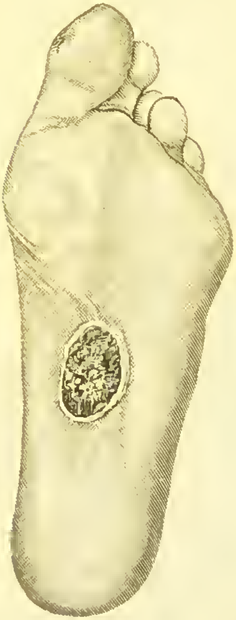
FIG. 70. — Melanotic Cancer of Sole of Foot.

The *treatment* consists in early and free removal of the primary growth, and of the associated lymphatic glands — whether these are enlarged or not. In the great majority of cases, when seen by the surgeon the disease is so far advanced that operative treatment holds out but little prospect of saving life.

Secondary Cancer of the Skin. — Cancer may spread to the skin from a subjacent growth by direct continuity or by way of the lymphatics. Both of these processes are well illustrated in cases of mammary cancer, and will be described along with diseases of the breast.

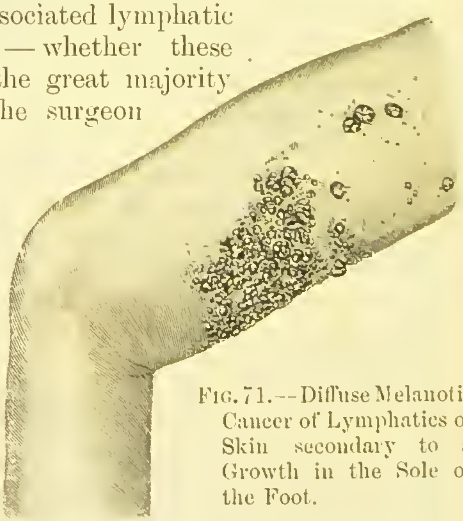
FIG. 71. — Diffuse Melanotic Cancer of Lymphatics of Skin secondary to a Growth in the Sole of the Foot.

Sarcomata of various types are met with in the skin. The most common is the alveolar sarcoma, which commences as a hard lump and steadily increases in size until the epidermis gives way and an ulcer is formed. A number of fresh tumours may spring up around the original growth. Sometimes the primary appearance is in the form of multiple nodules in the skin which tend to become confluent. Excision, unless performed early, is of little avail.

AFFECTIONS OF CICATRICES.

A cicatrix consists of closely packed bundles of white fibres covered by epidermis; the skin glands and hair follicles are usually absent. The size, shape, and level of the cicatrix depend upon the conditions which preceded healing. A healthy scar has a smooth, glossy surface of a pinkish colour when recently formed, but tending to become whiter as a result of obliteration of the blood-vessels concerned in its formation.

Weak Scars.—A scar is said to be weak when it readily breaks down as a result of irritation or pressure. The scars resulting from severe burns are especially liable to break down from trivial causes. The best treatment is to excise the weak portion of the scar and to cover the raw surface with Thiersch grafts.

Contracted scars are a frequent cause of deformity either by displacing parts, such as the eyelid or lip, or by fixing parts and preventing the normal movements—for example, a scar on the flexor aspect of a joint (Fig. 42). These are treated by dividing the scar, stretching it and filling up the gap with Thiersch grafts. When the deformity is due to the *depression of the scar* beneath the general skin level, as is not uncommon after the healing of a deeply seated abscess or sinus, the best treatment is to excise the scar and bring the edges of the gap together. The procedure known as "Adam's operation" consists in undercutting the scar with a tenotomy knife pushed in from the side, and maintaining it at the skin level by means of two hare-lip pins passed underneath it at right angles to each other. Another method of elevating depressed scars is by the subcutaneous injection of sterilised paraffin.

Painful Scars.—When there is marked pain in relation to a scar it is usually due to the implication of nerves in the cicatricial tissue; the nerve fibres are compressed or stretched, and in some cases there results an ascending neuritis. The treatment consists in excising the scar or in stretching or excising a portion of the nerve affected.

Pigmented or Discoloured Scars.—The best-known examples are the blue coloration which results from coal-dust or gunpowder, the brown scars resulting from chronic ulcer with venous congestion of the leg, and the variously coloured scars caused by tattooing. The only satisfactory method of getting rid of the coloration is to excise the scar; the edges are brought together by sutures, or the raw surface covered with Thiersch grafts according to the size of the gap.

Hypertrophied Scars.—Scars occasionally broaden out and become prominent. This may prove a source of disappointment after operations on the neck, such as those for goitre or tuberculous glands.

Keloid.—This term is applied to the overgrowth of scar tissue when it extends beyond the area of the original wound, and the name is derived from the fact that this extension usually occurs in the form of radiating processes, suggesting the claws of a crab. It is essentially a fibroma or new growth of fibrous tissue, which commences in relation to the walls of the smaller blood-vessels; the bundles of fibrous tissue are for the most part parallel with the surface, and the epidermis is tightly stretched over them.

Keloid may attack scars of the most diverse nature, such as those resulting from leech bites, acne pustules, boils or blisters, those resulting from operation or accidental wounds, and those resulting from burns (Fig. 41), especially when situated over the sternum. The scar becomes more and more conspicuous, is elevated above the surface, of a pinkish or brownish-pink colour, and sends out irregular prolongations around its margins. The patient may complain of itching and burning, and of great sensitiveness of the scar, even to contact with the clothing. There would appear to be an inherited predisposition to keloid. It is more frequent in the negro and in those who are, or have been, the subjects of tuberculous disease.

Treatment.—There is a natural hesitation to excise keloid because of the fear of its returning in the new scar. Such return is very unlikely if it be excised widely and the raw surface covered over with Thiersch grafts. The irritation associated with keloid may be relieved by the application of salicylic collodion or of salicylic and creasote plaster.

Epithelioma attacks scars which have repeatedly broken down in individuals who have reached the cancerous age. It has been observed in old people in the scar of a burn sustained in early childhood. It is not disseminated by the lymphatics until it has invaded the tissues outside the scar area. It should be excised widely; in the extremities it may be best to amputate the limb.

Affections of the Nails.

Injuries.—When a nail is contused or crushed, blood is extravasated beneath it. The blood becomes black and the nail is usually shed, a new one growing in its place. A splinter underneath the nail causes great pain, and if organisms are carried in along with it, may give rise to septic complications. The free edge of the nail should be clipped away to allow of the removal of the foreign body and of disinfection of the wound.

Trophic Changes.—The growth of the nails may be interfered with in any disturbance of the general health. The nails are apt to suffer along with the skin in nerve lesions, such as division of the nerve trunks of a limb, becoming curved, brittle, or furrowed, or they may be shed.

Onychia is the term applied to inflammation of the soft parts around the nail or of the matrix beneath it. The commonest form of onychia is that resulting from septic infection, which has already been referred to under "Whitlow." There is a superficial variety resulting from the extension beneath the nail of a purulent blister, lifting it up from its bed, and the pus is visible through the nail. The nail should be removed as well as the raised horny layer of the epidermis. A deeper and more troublesome onychia results from infection at the nail fold; the infection spreads very slowly beneath the fold until it reaches the matrix, and a drop or two of pus forms beneath the nail, usually in the region of the lunule. This affection entails a disability of the finger which may last for many weeks unless it is properly treated. The nail fold and lunule should be frozen and a considerable portion removed with the knife; if only a small portion of the nail is removed, the opening is blocked by granulations springing from the matrix. A new nail is formed.

Tuberculous onychia (O. maligna) is chiefly met with in children and adolescents. It appears as a livid or red swelling at the root of the nail, spreading around its margins. The epidermis, which is thin and shiny, gives way, exposing a weak ulcer, and the nail is usually shed. The treatment is the same as in other tuberculous lesions.

Syphilitic onychia assumes various aspects. A primary chancre at the edge of the nail may be mistaken for an ordinary whitlow, especially if it be attended with much pain. Other forms of onychia occur during secondary syphilis, simultaneously with the skin eruptions, and may prove very obstinate and lead to shedding of the nails. The nails are often markedly affected in inherited syphilis. In addition to general treatment, an ointment containing five per cent. of oleate of mercury should be applied locally.

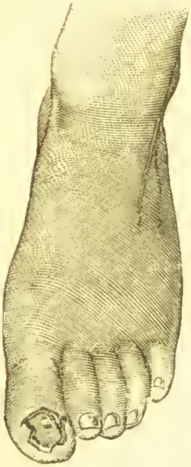
FIG. 72.—Ingrowing Toe-nail.

Ingrowing Toe-nail (lateral onychia).—This is more accurately described as an overgrowth of the soft tissues along the edge of the nail. It is most frequently met with in the great toe in young adults of either sex whose feet perspire freely, who wear ill-fitting shoes, and who cut their toe-nails carelessly or tear them with their fingers. Where the soft tissues are pressed against the edge of the nail, the skin is apt to ulcerate and lead to the formation of exuberant granulations and of a discharge which is sometimes fœtid. There is a good deal of pain, and the patient may be lame and unfitted for work. In mild cases the condition may be remedied by getting rid of any contributing causes and by disinfecting the skin and nail. The nail is then cut in an even circle, and the groove between it and the skin is packed with an antiseptic dusting-powder, such as boracic acid. In exceptional cases it may be necessary to remove one-half of the affected nail, and to prevent a relapse of the affection this must be carried out so that the portion of nail concerned is not reproduced.

Subungual exostosis is an osteoma growing from the terminal phalanx of the great toe (Fig. 73). It displaces the nail towards the dorsum, and may cause ulceration of the skin over the most prominent part of the growth. The nail should be reflected and the tumour removed with the chisel.

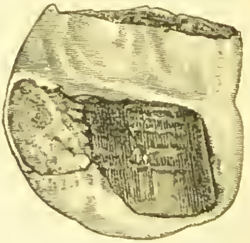
FIG. 73.—Subungual Exostosis.

(Anatomical Museum of the University of Edinburgh.)

Malignant disease in relation to the nails is very rare. Squamous epithelioma and melanotic cancer are the forms most likely to be met with. Treatment consists in amputating the digit concerned, and in removing the associated lymphatic glands.

CHAPTER XVIII.

THE MUSCLES, TENDONS, AND TENDON SHEATHS.

INJURIES: *Contusion; Sprain; Rupture*—Hernia of muscle—Dislocation of tendons—Wounds—Avulsion of tendon. DISEASES OF MUSCLE: *Atrophy; "Muscular rheumatism"; Contracture: Myositis; Ossification; Tumours.* DISEASES OF TENDONS AND OF TENDON SHEATHS: *Teno-synovitis.*

INJURIES.

Contusion of Muscle.—The violence which causes bruising of a muscle may act from without, as in blows, kicks, or falls; or from within, as by the displacement of a bone in fractures and dislocations. The lesion consists in rupture of blood-vessels and of muscle fibres.

The symptoms are those common to all contusions. The patient complains of severe pain on attempting to use the muscle, and maintains an attitude which will relax it. There is subcutaneous ecchymosis if the sheath of the muscle also is torn; sometimes the accumulation of blood results in the formation of a hæmatoma.

Repair is usually satisfactory; but when the nerve supplying the muscle is bruised at the same time, as is frequently the case in the deltoid, wasting and loss of function may be very persistent. In exceptional cases the process of repair may be attended with the formation of bone in the substance of the muscle.

Treatment consists in rest and the application of cotton wool and a bandage—followed, after an interval, by active movements, massage, and the use of the continuous current.

Sprain of Muscle.—This lesion consists in overstretching and partial rupture of the fibres of a muscle or its aponeurosis. It is of common occurrence in those who follow laborious occupations and in athletes. It may follow upon a single or on repeated efforts—especially in those who are out of training. Familiar examples of muscular sprain are the "labourer's" or "golfer's back," affecting the latissimus dorsi or erector spinæ; the "tennis-player's elbow," affecting the pronator radii teres; the "angler's elbow," affecting the common origin of the extensors and supinators; the "sprinter's sprain," affecting the flexors of the hip, and the "jumper's sprain," affecting the muscles of the calf. The patient complains of pain, often sudden in onset, of tenderness on pressure, and of inability to carry out the particular movement by which the sprain was produced. The disability varies in different cases, and it may incapacitate the patient from following his occupation or sport for weeks or even months.

The *treatment* consists in resting the muscle from the particular effort concerned in the production of the sprain, in gently exercising it in other directions, and in the use of massage.

Rupture of Muscle or Tendon.—A muscle or a tendon may be ruptured in its continuity or torn from its attachment. The site of rupture in individual muscles is remarkably constant, and is most often at the junction of the muscle with its tendon. When rupture takes place through the belly of a muscle the ends retract, the amount of retraction depending on the length of the muscle between its points of attachment, and the extent of its adhesion to adjacent aponeurosis or bone. The biceps in the arm, and the sartorius in the thigh, furnish examples in which the separation between the ends may be considerable.

The space in the muscle becomes filled with blood, and this in time is replaced by connective tissue, which forms a bond of union between the ends. Where the gap is considerable the connecting medium consists of fibrous tissue, but where the ends are approximated it may contain a number of newly formed muscle fibres. In the process of repair, one or both ends of the muscle or tendon may become fixed by adhesions to adjacent structures. If the distal portion of a muscle is cut off from its nerve supply it may undergo degeneration.

The rupture of a muscle or tendon is usually the result of a sudden, and often involuntary, movement. As examples we may cite the rupture of the quadriceps extensor in attempting to regain the balance when falling; of the gastrocnemius, plantaris, or tendo Achillis in jumping or dancing; of the adductors of the thigh in gripping a horse when it swerves; of the abdominal muscles in vomiting, and of the biceps flexor cubiti in sudden movements of the arm. Sometimes the effort is one that would scarcely be thought likely to rupture a muscle, as in the case recorded by Pagenstecher, where a professional athlete, while sitting at table, ruptured his biceps in a sudden effort to catch a falling glass. It would appear that the rupture is brought about not entirely by the contraction of the muscle concerned, but by the contraction of the antagonistic muscles taking place before that of the muscle which undergoes rupture is completed. The violent muscular contractions of epilepsy, tetanus, or delirium rarely cause rupture. Muscles may also be ruptured by a direct stroke or by a crush of the part.

The *clinical features* are usually characteristic. The patient experiences a sudden pain, with a sensation of being struck with a whip, and of something giving way, and sometimes a distinct snap is heard. The limb becomes powerless. At the seat of rupture there is tenderness and swelling, and there may be ecchymosis. As the swelling subsides a gap may be felt between the retracted ends, and this becomes wider when the muscle is thrown into contraction. If left untreated, a narrow, hard, fibrous cord may be felt at the seat of the rupture.

Treatment.—The ends are approximated by relaxing the muscle, and the attitude required is maintained by bandages, splints, or special apparatus. Where it is impossible to approximate the ends satisfactorily by these measures, the muscle or tendon is exposed and the ends brought into accurate contact by catgut sutures. This operation of primary suture is most successful when it is done within five or six days of the accident. Secondary suture after an interval of months is rendered difficult by the retraction of the ends and by their adhesion to adjacent structures.

Rupture of the biceps of the arm may involve the long or the short head, or the belly of the muscle. Most interest attaches to rupture of the long head or of its tendon of origin. There is pain and tenderness in front of the humerus, the patient is unable to abduct or to elevate the arm, and he may be unable to flex the elbow when the forearm is supinated. The long axis of the muscle, instead of being parallel with the humerus, inclines downwards and outwards. On contraction the belly of the muscle is displaced downwards towards the elbow.

The *quadriceps extensor femoris* is usually ruptured on one or on both sides close to its insertion into the patella, in the attempt to save one's self from falling backwards. The limb is rendered useless for progression, as it gives way on slight flexion. Treatment is conducted on the same lines as in transverse fracture of the patella; in the majority of cases the continuity of the quadriceps should be re-established by suture within five or six days of the accident.

The *tendo Achillis* is comparatively easily ruptured, and if the symptoms are not well marked the injury may be overlooked. The limb should be put up with the knee flexed and the toes pointed. This may be effected by attaching one end of an elastic band to the heel of a slipper, and securing the other end to the lower third of the thigh. If this is not satisfactory, the ends may be approximated by sutures.

Partial rupture of muscle is produced in the same way, and affects the same muscles, as complete rupture. There is pain and tenderness increased by movement, and there may be an appreciable gap in the continuity of the muscle, which, however, does not show the same tendency to increase when the muscle contracts as it does when the rupture is complete. The treatment consists in rest and massage, followed by movements and exercises calculated to restore the functions of the muscle.

Hernia of Muscle.—This is a rare condition, in which the fascia covering a muscle becomes stretched or torn, and the muscular substance is protruded through the rent, constituting a hernia. It has been chiefly observed in the adductor longus of those who are learning to ride. The patient exhibits an oval swelling in the upper part of the thigh, which is soft and prominent when the muscle is relaxed, is less prominent when it is passively extended, and becomes small and hard when the muscle is thrown into contraction. It may cause no inconvenience, or may be associated with a feeling of weakness and of being easily tired. It is liable to be mistaken, according to its situation, for a tumour, a cyst, a pouched vein, or an abdominal hernia. In some cases no treatment is called for. If it is causing inconvenience, the muscle is exposed by a suitable incision, and if there is a rent in the sheath this may be closed by sutures after reducing the hernia. If this is impossible the herniated portion of muscle is excised.

Dislocation of Tendons.—Tendons which run in grooves may be displaced as a result of the rupture of the confining sheath. This injury is chiefly met with in relation to the tendons at the ankle and in the long tendon of the biceps.

Dislocation of the *peronei tendons* may be met with—for example, in a patient who has recently sustained a violent twist of the foot. There is severe pain and considerable swelling in the region of the outer ankle; the peroneus longus by itself, or together with the brevis, is found lying on the outer aspect or in front of the external malleolus; the patient is unable to move the foot. By a little manipulation the tendons are replaced in their grooves, and are retained there by a series of strips of plaster. At the end of three weeks massage and exercises are employed.

Sometimes the displacement occurs apart from a definite injury. Whenever the foot is everted the tendon of the peroneus longus is liable to be jerked forwards out of its groove, sometimes with an audible snap. The patient is pained and disabled until the tendon is replaced. Reduction is easy, but the displacement tends to recur at frequent intervals. Under these conditions an incision should be made over the tendon; if the sheath is merely slack or is torn, it is tightened up or closed with catgut sutures; or an artificial sheath is made by raising up a quadrilateral flap of periosteum from the outer aspect of the fibula, and stitching it over the tendon.

Similarly the *tibialis posticus* may be displaced over the internal malleolus as a result of inversion of the foot.

The *long tendon of the biceps* may be dislocated outwards or inwards—usually inwards—as a result of violent or of repeated rotation movements of the upper arm, such as are performed in wringing clothes. The patient is aware of the displacement taking place, and is unable to extend the forearm until the displaced tendon has been reduced by abducting the arm. In recurrent cases the patient may be able to dislocate the tendon at will, and in such cases the disability is so inconsiderable that there is rarely any occasion for interference.

Wounds of Muscles and Tendons.—Accidentally inflicted wounds of muscles are to be treated on the same lines as wounds of other soft structures. After thorough disinfection they should be stitched with catgut. If they are allowed to retract or if the wound suppurates, the ends are united by scar tissue and may become fixed to bone or other adjacent structures. In the limbs this may interfere with the functions of the muscle: in the abdominal wall the scar tissue may stretch and yield, and so favour the development of a ventral hernia.

Tendons may be cut across accidentally, especially in those wounds so commonly met with above the wrist. It is essential that the ends should be carefully sutured to each other, and as the upper end is retracted the original wound may require to be enlarged in an upward direction. When primary suture has been omitted, or has failed in consequence of suppuration, the separated ends of the tendon become adherent to adjacent structures, and the function of the associated muscle is impaired or lost. Under these conditions the operation of secondary suture is indicated. A free incision is necessary in order to discover and isolate the ends of the tendon; if the interval is too wide to admit of their being approximated by sutures, one or both ends must be lengthened by splitting it longitudinally in order to bridge the gap.

Avulsion of Tendons.—This is a rare injury in which the tendons of a finger or toe are torn from their attachments along with the digit concerned. In the hand it is usually brought about by the fingers being caught in the reins of a runaway horse or being seized in a horse's teeth. It is usually the terminal phalanx that is separated, and with it the tendon of the deep flexor which ruptures most frequently at its junction with the belly of the muscle in the forearm. The treatment consists in disinfecting the wound, closing the tendon sheath, and trimming the mutilated finger so as to provide a useful stump.

Diseases of Muscle.

Congenital absence of one or more muscles may be met with, usually in association with other congenital deformities. The pectoralis major, for example, may be absent on one or on both sides, without, however, causing any disability, as other muscles enlarge and take on its functions.

Atrophy of Muscle.—There is a form of atrophy or wasting of muscles described as "simple" because the muscle elements are merely diminished in size without undergoing any structural alteration. It is commonly met with as a result of disuse, as when a patient is confined to bed with a fracture. In cases of bone disease, and to a still more marked degree in joint disease, the muscles of the affected region become atrophied more rapidly than is accounted for by disuse alone. This is attributed to an interference with the trophic innervation of the muscles reflected from centres in the spinal cord. So decided is the atrophy that it is commonly recognised as an evidence of the existence of joint disease. It is usually more marked in the extensor than in the flexor groups of muscles. The affected muscles become soft and flaccid, they exhibit tremors on attempted movement, and their excitability to the faradic current is diminished.

There is also a form of atrophy which may be described as *neuropathic* because of its association with lesions of the nervous system. It is most pronounced in lesions of the motor nerve trunks, probably because vasomotor and trophic fibres are involved as well as those which are purely motor in function. It is attended with definite structural alterations, the muscle elements first undergoing fatty degeneration, and then being absorbed, and replaced to a large extent by ordinary connective tissue and fat. The affected muscles exhibit the reaction of degeneration.

"**Muscular Rheumatism.**"—This clinical term is applied to a group of affections of which lumbago is the best-known example. The group includes lumbago, stiff-neck, and pleurodynia—conditions which have this in common, that sudden and severe pain is excited in the part by movement.

In *lumbago* the pain is usually located over the sacrum, the sacro-iliac joint, or aponeuroses of the lumbar muscles on one or both sides. The amount of tenderness varies, but so long as the patient is perfectly quiet he is free from pain. The slightest attempt to alter the position of the back, however, is attended by pain, which may be so severe as to render him helpless for the moment. The pain is most marked on rising from the stooping position. The pain may shoot down the back of the hip, thus simulating sciatica, or the patient may suffer from lumbago and sciatica at the same time. Once a patient has suffered from lumbago, it is very liable to recur, and an attack may be determined by errors of diet, by changes of weather, and by exposure to cold. It is chiefly met with in male adults, and is most apt to occur in those who are gouty or rheumatic, or the subjects of oxaluric dyspepsia.

In "*painful stiff-neck*" or rheumatic torticollis the pain is located in one side of the neck, and is excited by some inadvertent movement. The head is held stiffly on one side as in wry-neck, the patient voluntarily contracting the sterno-mastoid. There may be tenderness over the vertebral spines or in the lines of the cervical nerves, and the sterno-mastoid may undergo atrophy. This affection is as common in children as in adults.

In *pleurodynia* the pain is located to the side of the chest, in the line of the intercostal nerves, and is excited by movements of the chest, as in coughing, or by any bodily exertion. There is often marked tenderness.

A similar affection is met with in the *shoulder*, especially on waking from sleep. There is acute pain on attempting to abduct the arm, and there may be localised tenderness in the region of the circumflex nerve.

It would appear that these conditions, which have hitherto been regarded as specially affecting muscles, are in many cases dependent on a nerve lesion such as neuritis or on some joint affection.

Treatment.—The general treatment is concerned with the diet, attention to the stomach, bowels, and kidneys, and with the correction of any gouty or rheumatic tendencies that may be present. The patient must persevere with movements and exercises, excepting those which specially excite the pain, and must avoid exposure to cold when heated. Great benefit may be derived from massage, and from the use of the battery, especially in cases in which the nerves are involved. In severe cases of lumbago, exercises are out of the question until the excessive pain and helplessness have been overcome by the application of heat, as by a hot-bottle or mustard poultice. Cupping or needling, or, in exceptional cases, hypodermic injections of antipyrin or morphin may be called for. To prevent relapses of lumbago, the patient must take systematic exercises of all kinds, especially those which bring out the movements of the spinal column and hips, such as cycling.

Contracture of Muscles.—Permanent shortening of a muscle may result from the prolonged approximation of its points of attachment, or from structural changes in its substance produced either by injury or by disease. It is a frequent accompaniment, and sometimes a cause of certain deformities, in the treatment of which division of the contracted muscle or muscles may be an essential step.

An aggravated form of contracture sometimes follows upon the prolonged anæmia of muscles, such as is caused by tight bandaging or the use of the elastic tourniquet—*Volkmann's ischæmic paralysis.* In the upper extremity the muscles of the forearm undergo degeneration, and by contracting cause a claw-like deformity of the hand and fingers. The tendons of the contracted muscles may require to be divided and lengthened.

Myositis.—Various forms of inflammation of *pyogenic* origin are met with in muscle, most frequently in relation to pyæmia and to typhoid fever. These may result in overgrowth of the connective-tissue framework of the muscle and degeneration of its fibres, or in suppuration and the formation of one or more abscesses in the muscle substance. Repair may be associated with contracture. An evanescent form of myositis, attended with considerable pain, may be met with as a result of gonorrhœa.

In the early secondary period of *syphilis*, the muscles may be the seat of dull, aching, nocturnal pains, especially in the neck and back. Reference must also be made to what is known as *syphilitic contracture*, a condition which has been chiefly observed in the later secondary period. The biceps of the arm, and the hamstrings in the thigh, are those most commonly affected. The striking feature is a gradually increasing difficulty of extending the limb at the elbow or knee, and progressive flexion of the joint. The affected muscle is larger and firmer than normal, and its electric excitability is diminished. In tertiary syphilis individual muscles may become the seat of interstitial myositis or of gummata, both of these being well illustrated in the muscles of the tongue. All of these affections readily yield to anti-syphilitic remedies.

Tuberculous disease in muscle, while usually due to extension from adjacent tissues, is sometimes the result of a primary infection through the blood-stream. Tuberculous nodules are found disseminated throughout the muscle. The surrounding tissues are indurated, and central caseation may take place and lead to abscess formation and sinuses. We have observed this primary form of tuberculous disease in the gastrocnemius and in the psoas—in the latter muscle apart from tuberculous disease in the vertebræ.

Ossification in Muscles, Tendons, and Fasciæ — *Myositis Ossificans.*—Reference may be made in the first place to the very common ossifications met with in muscles, tendons, fasciæ, and ligaments in those who are the subjects of arthritis deformans. They are seldom recognised clinically, but are frequently met with in the dissecting-room and in museums. Similar localised ossifications are met with in Charcot's disease of joints, in long-standing cases of leg ulcer (Fig. 16), and in fractures which have repaired with exuberant callus. The new bone may be in the form of spicules, plates, or irregular masses, which, when they are connected with a bone, are sometimes called *false* or *spurious exostoses.*

Another variety of ossification in muscle is that met with as a result of injury. Ossification in the crureus or vastus externus muscle has been chiefly observed after a severe blow on the thigh—such, for example, as a kick from a horse. Within a week or two a tumour appears at the site of injury, and becomes progressively harder until its consistence is that of solid bone. If the tumour moves with the affected muscle it causes but little inconvenience. If, as is commonly the case, it is fixed to the subjacent bone, the action of the muscle is impaired, and the patient complains of pain and difficulty in flexing the knee. In skiagrams the tumour yields a shadow which may or may not be continuous with that of the femur. The treatment consists in excising the bony mass. In some cases a hæmatoma with a fibrous wall and smooth lining membrane is found overlying the bony tumour.

A similar ossification has been observed in the brachialis anticus interfering with the movements of the elbow.

Ossification in the adductor longus was first described by Billroth under the name of "rider's bone." It is believed to be due to bruising and partial rupture of the muscle, and has been observed chiefly in cavalry soldiers. It causes little inconvenience, and is usually discovered accidentally as an induration in the substance of the muscle.

Ossification in the left deltoid and pectoral muscles has been observed in foot-soldiers in the German army, and has secured the name of "drill-bone."

Lastly, there is the interesting generalised disease—*progressive ossifying myositis*—in which the muscles, tendons, and fasciæ throughout the body are converted into bone. It affects almost exclusively the male sex, and is sometimes associated with congenital deformities of the fingers and toes. It usually begins in childhood or youth, sometimes after an injury, sometimes without any apparent cause. The muscles of the back, especially the trapezius and latissimus, are the first to be affected. They may become swollen and tender, or the initial complaint may be of limitation of movement. On examination the bony nodules are seen and felt, and may be shown in skiagrams. As time goes on these bony nodules increase in number and size, and tend to become fused together into larger masses. The spine becomes rigid, the head is bent forward, the hips are flexed, and abduction and other movements of the arms limited. The disease progresses by fits and starts until all the striped muscles of the body may be ossified, and all movements, even those of the jaws, may be abolished. It is generally fatal within ten or twelve years from its onset, death usually resulting from pulmonary complications. There is no means of arresting the disease, and treatment is restricted to improving the general health, and to the removal of any mass of bone which interferes with an important movement.

The bone found in muscle is derived from its connective-tissue framework, and the muscle fibres themselves undergo atrophy and absorption. The bone is spongy in character, and its development takes place along similar lines to those normally observed in the periosteum.

Tumours of Muscle.—With the exception of certain rare congenital varieties, such as the rhabdomyoma, tumours of muscle grow from the connective-tissue framework and not from the muscle fibres. Innocent tumours, such as the fibroma, lipoma, angioma, and neuro-fibroma, are very rare. Malignant tumours may be primary in the muscle, or may result from extension from adjacent growths—for example, implication of the pectoral muscle in cancer of the breast—or may be derived by metastasis from tumours situated elsewhere. The diagnosis of an intramuscular tumour is made by observing that the swelling is situated beneath the deep fascia, and that it becomes firm and fixed when the muscle is contracted. When the muscle is relaxed, the tumour becomes softer, and can be moved in the transverse axis of the muscle, but not in its long axis. The same remarks apply to a gumma or mass of bone within the muscle.

Clinical interest chiefly attaches to that form of slowly growing fibro-sarcoma—*the recurrent fibroid of Paget*—which is most frequently met with in the muscles of the abdominal wall. A rarer variety is the chondro-sarcoma, which may undergo ossification to such an extent as to be appreciable in skiagrams.

In primary sarcoma the treatment consists in removing the muscle. In the limbs the function of the muscle which is removed may be retained by transplanting an adjacent muscle in its place. We have carried this out in an ossifying sarcoma of the muscles of the calf by stitching the divided peroneus longus into the tendo Achillis.

Hydatid cysts of muscle are very rare.

DISEASES OF TENDONS AND OF TENDON SHEATHS.

Tendon sheaths have the same structure and function as the synovial membranes of joints, and are liable to the same diseases.

Teno-synovitis.—The toxic or infective agent causing inflammation of tendon sheaths is either conveyed to them through the blood-stream, as in the gouty, gonorrhœal, and tuberculous varieties, or is introduced directly through a wound, as in the common form of septic teno-synovitis.

"Simple" Teno-synovitis.—In the so-called simple or traumatic teno-synovitis, although the most prominent etiological factor is a strain or over-use of the tendons, there is some other, probably a toxic, factor in its production, otherwise the affection would be much more common than it is. Only a very small proportion of those who strain or over-use their tendons become the subjects of teno-synovitis. It is usually excited by the excessive use of certain tendons in those who are predisposed by constitutional peculiarity or by the presence of

some toxin in the blood. It is common in the tendons at the wrist, and especially in the extensors of the thumb. In certain occupations—in riveters, in washerwomen, pianists, fencers, and in those who row—it is frequently met with. At the ankle it may affect the peronei, the extensor longus digitorum, or the tibialis anticus, but it is most often met with in relation to the tendo Achillis. This affection, which is known as *Achillo-dynia*, results from the pressure of ill-fitting boots or from the excessive use and strain of the tendon in cycling, walking, or dancing. There is pain and difficulty in raising the heel from the ground, and there is well-marked crepitation or creaking when the tendon is moved beneath the examining fingers. It readily subsides under rest and the application of a blister, but it is apt to relapse on a repetition of the exciting cause. In the upper arm the sheath of the long tendon of the biceps may be affected.

The anatomical changes resemble those observed in a dry pleurisy; there is an exudation of fibrinous lymph onto the surface of the tendon and its sheath, so that there is friction when these surfaces rub together.

The *clinical features* are pain on movement, tenderness on pressure over the affected tendon, and a sensation of crepitation or friction when the tendon is moved in its sheath. The crepitation may be soft like the friction of snow, or may resemble the creaking of new leather—"saddle-back creaking." There may be swelling in the long axis of the tendon, and redness and œdema of the skin. If there is an effusion of fluid into the sheath, the swelling is more marked and crepitation is absent. The affection subsides in a few days under rest, but is liable to relapse on a renewal of the exciting cause. There is usually little tendency to the formation of adhesions.

Treatment.—When the extensor tendons of the thumb or fingers are affected, the pain is relieved by lead and opium fomentations, or by glycerin and belladonna, and the forearm and hand should be immobilised on a palmar splint. The later treatment consists in massage and movement of the thumb and fingers. Any constitutional or gastro-intestinal derangement should be corrected by appropriate diet and medicinal treatment.

Gouty Teno-synovitis.—The deposit of urate of soda beneath the endothelial covering of tendons or of that lining their sheaths is commonly met with in gouty subjects. The accumulation of urates may result in the formation of visible nodular swellings, varying in size from a pea to a cherry, which are attached to the tendon and move with it. They may be merely unsightly, or they may interfere with the use of the tendons. Recurrent attacks of inflammation sometimes occur. We have removed gouty masses on account of one or other of these indications, with satisfactory results.

Suppurative Teno-synovitis.—This form usually follows upon infected wounds of the fingers—especially of the thumb or little finger—and is a frequent sequel to whitlow. It may also follow amputation of the fingers. Once the infection has gained access to the sheath, it tends to spread, and may reach the palm or even the forearm, being then associated with cellulitis. There is considerable fever, pain, and swelling. Pus frequently forms. In moderately acute cases the tendon and its sheath become covered with granulations, which subsequently lead to the formation of firm adhesions; while in very acute cases the tendon generally sloughs. Pus may burst into the cellular tissue outside the sheath, and the suppuration may spread to neighbouring sheaths or to adjacent bones or joints—for example, those of the wrist.

The *treatment* consists in early incision of the sheath. Several incisions are usually required, and drainage-tubes are then introduced. As soon as the inflammation has subsided, active and passive movements are to be employed in order to prevent the formation of adhesions between the tendon and its sheath. If the tendon sloughs, the dead portion should be removed, as its separation by nature is extremely slow. The treatment of whitlow has been already described.

Gonorrhœal Teno-synovitis.—This is by no means rare, especially in the tendon sheaths about the ankle. It may occur in a mild form, with pain, impairment of movement, and œdema, and sometimes an elongated, fluctuating swelling forms, the result of serous effusion into the sheath. In the more severe variety the skin is red, and the swelling partakes of the characters of a phlegmon with threatening suppuration. While the sheath may be filled with pus, the tendon rarely sloughs. This condition may alternate with a gonorrhœal affection of one of the large joints. It usually subsides under rest and soothing applications, but is liable to relapse. The suppurative form should be incised and drained.

Tuberculous Disease of Tendon Sheaths.—This is a comparatively common affection, and is analogous to tuberculous disease of the synovial membrane of joints. It may originate in the sheath, or may spread to it from disease in an adjacent bone.

The commonest form is that in which the synovial sheath is distended with fluid containing melon-seed bodies—a condition formerly known as *hydrops* or *hygroma* of tendon sheaths. The sheath itself is thickened by the growth of tuberculous granulation tissue, which subsequently undergoes degeneration. On the free surface the fibrinous material is detached and moulded into melon-seed bodies by the movements of the tendon. These bodies vary greatly in size and shape, are of a dull-white colour, and have a smooth surface (Fig. 217). They consist of a material resembling fibrin, which is usually homogeneous, but is sometimes arranged in a laminated or reticulated fashion. Cellular elements may be scattered throughout its substance, but they rarely exhibit the arrangement of tubercle follicles, and it is seldom possible to demonstrate tubercle bacilli in them. The melon-seed bodies are usually suspended in a clear or slightly turbid, yellowish, viscous fluid. There may be an overgrowth of the fatty fringes of the synovial sheath, a condition described as "arborescent lipoma."

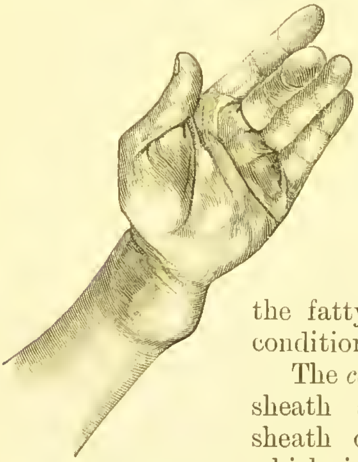

Fig. 74.—Tuberculous Disease of Sheaths of Flexor Tendons.

(Mr. J. M. Cotterill's case.)

The *clinical features* vary with the tendon sheath affected. In the common flexor sheath of the hand a swelling is formed, which is hour-glass-shaped, bulging above and below the annular ligament—the so-called *compound palmar ganglion* (Fig. 74). There is little or no pain, but the fingers tend to be stiff and weak, and they may become flexed. On palpation it is usually possible to displace the contents of the sheath from one compartment to the other, and this may yield fluctuation, and, what is more characteristic, a peculiar friction or crepitation from the movement of the melon-seed bodies against one another. In the flexor sheath of a finger the swelling is confined to the finger. In the sheath of the peronei or other tendons about the ankle the swelling is sausage-shaped, with a constriction opposite the annular ligament.

The onset and progress of the affection are most insidious, and the condition may remain stationary for long periods. It is aggravated by use or strain of the tendons involved. In exceptional cases the skin becomes thinned and gives way, leading to the formation of a discharging sinus. The prognosis is influenced by the general condition of the patient and the existence of tuberculous lesions elsewhere in the body.

The *treatment* is conducted on the same lines as for a cold abscess. The distended sheath is laid open, the contents evacuated, the wall scraped and swabbed out with pure carbolic acid, and the wound closed. In the common flexor sheaths of the palm an attempt may be made to cure the condition by removing the contents through a small incision and filling the cavity with iodoform emulsion. Movement of the fingers is an important element in the after treatment.

A less common form of tuberculous disease is that in which the sheath becomes the seat of *a diffuse tuberculous thickening*, not unlike the white swelling met with in joints, and with a similar tendency to caseation. There is an absence of fluid and of melon-seed bodies. A painless swelling of an elastic and tumour-like character forms in relation to the tendon sheath. It is hour-glass-shaped in the common flexor sheath of the palm, elongated or sausage-shaped in the extensors of the wrist and in the tendons at the ankle. Although resembling the previous form in being slow in progress and of long duration, it is more liable to result in invasion of the tendons and interference with their functions. It is also more liable to break down and lead to the formation of abscesses and sinuses, and in our experience is more often associated with disease in the adjacent bone or joint. In the peronei tendons, for example, it may be associated with, and result from, disease of the fibula or of the ankle-joint.

The diagnosis is easy as a rule, but the local appearances closely resemble those of innocent tumours of tendon sheaths.

Treatment.—Excision of the affected sheath is the only satisfactory treatment. The whole of the diseased area must be exposed by free incision of the overlying soft parts; the sheath is then carefully isolated from the surrounding tissues and cut across above and below. Any tuberculous tissue on the tendon itself is removed with a sharp spoon. Associated bone or joint lesions are dealt with at the same time. In the after treatment the functions of the tendons must be preserved by active and passive movements.

Syphilitic Affections of Tendon Sheaths.—These closely resemble the syphilitic affections of the synovial membrane of joints. During the secondary period the lesion usually consists in effusion into the sheath; gummata are met with during the tertiary period.

Tumours of Tendon Sheaths.—Innocent tumours are very rare. Their clinical features resemble tuberculous disease so closely that the diagnosis is rarely made before operation. In addition to the *lipoma*, *fibroma*, and *myxoma*, special mention should be made of the *myeloma*. This is met with either at the wrist or ankle as an elongated swelling of slow development. The tumour tissue, when exposed by dissection, is of a chocolate or chamois-yellow colour, and consists almost entirely of giant cells. The treatment consists in dissecting the tumour tissue off the tendons; recurrence is the exception. All varieties of *sarcoma* are met with, but their origin from tendon sheaths is not associated with any special features. In removing them it may be necessary to sacrifice the tendons or to amputate the limb.

CHAPTER XIX.

THE BURSÆ.

Anatomy—Normal and adventitious bursae—Injuries: Bursal hæmatoma —DISEASES: Traumatic or trade bursitis; Bursal hydrops; Solid bursal tumour; Gonorrhœal and suppurative forms of bursitis; Tuberculous and syphilitic disease—Tumours—*Diseases of individual bursæ in the upper and lower extremity.*

A BURSA is a closed sac lined by endothelium and containing synovial fluid. Bursæ occur where two surfaces rub against one another, and they serve to diminish friction. Some are normally present—for example, in front of the knee and over the point of the elbow. Others are developed in situations where undue pressure is applied—for example, in relation to deformities. Such *adventitious bursæ* are common over the tarsal bones in certain cases of club-foot.

The lining membrane of bursæ resembles that of joints and tendon sheaths, and is liable to the same forms of disease.

Injuries of Bursæ.—As a result of contusion, hæmorrhage may occur into the cavity of a bursa and give rise to a bursal hæmatoma. This is especially liable to occur in bleeders. Such a hæmatoma may mask a fracture of the bone beneath—for example, fracture of the olecranon process. Acute suppuration is a frequent sequel of infected wounds.

Diseases of Bursæ.—The various forms of inflammation met with in bursæ correspond very closely to those occurring in tendon sheaths.

Traumatic or "Trade" Bursitis.—This term may be conveniently employed to include certain affections of bursæ which are characterised by an effusion of fluid into the cavity with more or less thickening of the lining membrane of the sac. While friction and pressure constitute the most prominent factors in its production, it is probable that there is also some toxic agent concerned, otherwise the affection would be much more common than it is. Of the countless housemaids in whom the prepatellar bursa is subjected to friction and pressure, only a small proportion become the subjects of the typical form of traumatic bursitis known as "housemaid's knee." The traumatic element, however, is so obvious in the causation of this form of bursal enlargement, and its occurrence in certain occupations is so common, that the general term "trade-bursitis" has been applied to it.

The *clinical features* vary in different cases. Taking *prepatellar bursitis*—the so-called housemaid's knee—as the type, we find that sometimes, and especially in acute cases, the part is hot, swollen, and tender, and fluctuation may be detected in the bursa. The patient may be obliged to lie up. In the majority of cases the chief feature is the gradual accumulation of fluid constituting the *bursal hydrops* or *hygroma*. Where the affection has lasted some time, or has frequently relapsed, the wall of the bursa becomes thickened by newly formed fibrous tissue. This may take place in a uniform and concentric fashion, resulting in the formation of a fibrous tumour—*the solid bursal tumour*—a small cavity containing a little fluid remaining in the centre. Or the fibrous thickening may be quite irregular and result in the formation of septa, bands or fringes not unlike those met with in arthritis deformans. The detachment of fringes may give rise to loose bodies like those met with in joints. Less frequently there are fibrinous bodies of the melon-seed type, sometimes moulded into circular discs like wafers. The presence of irregular thickenings of the wall, or of loose bodies, may be recognised clinically—especially in superficial bursæ, and when the sac is not tensely filled with fluid.

The *treatment* varies according to the variety and stage of the affection. In recent cases the symptoms subside under rest and the application of carbolic or lead and opium fomentations. Hydrops is got rid of by blistering, by tapping, or by incision and drainage. When the wall is thickened the most satisfactory treatment is to excise the bursa. The overlying skin should be reflected downwards in the shape of a horse-shoe flap.

Similar forms of bursitis are associated with *gonorrhœal infection*, and with *rheumatism*—especially that following scarlet fever—and are apt to be very persistent or to relapse after apparent cure. In *gout*, urate of soda is deposited in the wall of the bursa, and may result in the formation of chalky tumours, sometimes of considerable size.

The *suppurative form* may be due to the extension of an adjacent inflammation—for example, from suppuration in a joint or in the cellular tissue; but it usually results from an infected wound implicating the bursa, or the skin and subcutaneous tissue over it. It is most frequently met with in the olecranon bursa after a fall on the point of the elbow, and may run a very acute course. There is redness of the skin, great swelling and œdema of the arm, and if untreated the septic process may transgress the wall of the bursa, invade the surrounding cellular tissue, and spread up and down the limb. The condition may simulate erysipelas. The corresponding affection in the prepatellar bursa may also assume serious proportions. Treatment is conducted on general principles.

Tuberculous disease of bursæ closely resembles that of tendon sheaths. It may occur as an independent affection, or may be associated with tuberculous disease in an adjacent bone or joint It is chiefly met with in the prepatellar and subdeltoid bursæ, or in one of the bursæ over the great trochanter. The clinical features are those of an indolent hydrops, with or without melon-seed bodies, or of uniform thickening of the wall of the bursa, which sometimes breaks down into a cold abscess and gives rise to persistent sinuses. The best treatment is to excise the affected bursa, or, where this is impracticable, to lay it freely open, remove the softened tuberculous tissue with the sharp spoon, and treat the resulting cavity by the open method.

Syphilitic disease is rarely recognised except in the form of bursal and peri-bursal gummata in front of the knee-joint.

Tumours of bursæ include the fibroma, the myxoma, the myeloma or giant-celled tumour, and various forms of sarcoma. They present the same clinical features, and are treated on the same lines, as similar tumours elsewhere.

Diseases of Individual Bursæ.—In the upper extremity the *olecranon* bursa is that most frequently affected. The enlargement usually results from friction and pressure, and is known as the "miner's" or "student's elbow." The *subdeltoid* bursa may be distended with fluid and melon-seed bodies—especially as a result of tuberculous disease—constituting a prominent swelling on the outer aspect of the shoulder. Mention should also be made of the bursa underneath the tendon of the *subscapularis* muscle, disease of which causes impairment of the movements, and alteration in the attitude of the shoulder; and of the adventitious bursa which forms over the *acromion* process in porters and others who carry weights on the shoulder.

In the lower extremity a large number of normal and adventitious bursæ are met with. That over the *tuberosity of the ischium* when enlarged as a trade disease is known as "weaver's" or "tailor's bottom." It may form a fluctuating swelling of great size, projecting on the buttock and extending down the thigh, and causing great inconvenience in sitting (Fig. 75). There are two bursæ over the *great trochanter*, one superficial to and one beneath the aponeurosis of the gluteus maximus; the latter is not infrequently infected by tuberculous disease spreading from the trochanter.

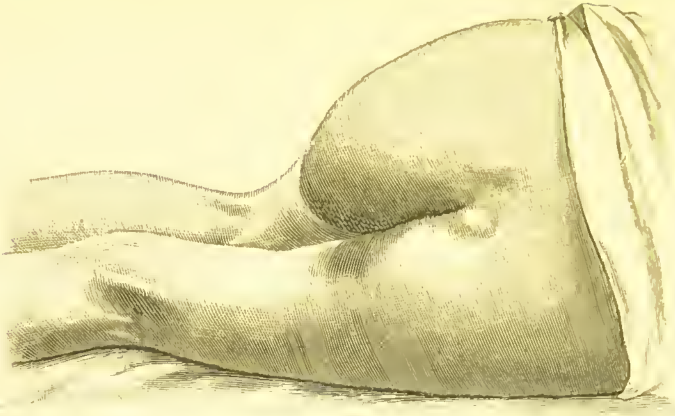
FIG. 75.—Great Enlargement of the Ischial Bursa.
(Mr. Scot Skirving's case.)

Disease of the bursa between the *psoas* and the capsule of the hip-joint is associated with clinical features not unlike those of hip disease. The limb may be flexed, abducted and rotated out, and there is a distinct swelling in the upper part of Scarpa's triangle.

The bursa beneath the quadriceps extensor — *subcrural bursa* — usually communicates freely with the knee-joint and shares in its diseases. When shut off from the knee it may suffer independently, and when distended with fluid forms a horse-shoe swelling above the patella (Fig. 76).

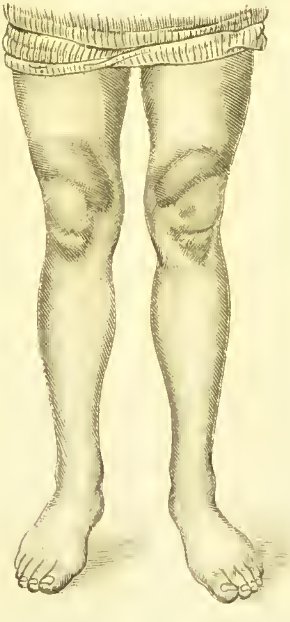
FIG. 76.—Bilateral Hydrops of Subcrural Bursa.
(Mr. F. M. Caird's case.)

In front of the *patella and its ligament* there may be one, two, or three bursæ, usually communicating with one another. Enlargement of one or other of these is known as housemaid's knee—which has already been described. The bursa *between the ligamentum patellæ and the tibia* is very rarely the seat of independent disease. There is pain and tenderness referred to the ligament, the patient is unable to extend the limb, the tubercle of the tibia is apparently enlarged, and there is a fluctuating swelling on either side of the ligament, most marked in the extended or semiflexed position of the limb.

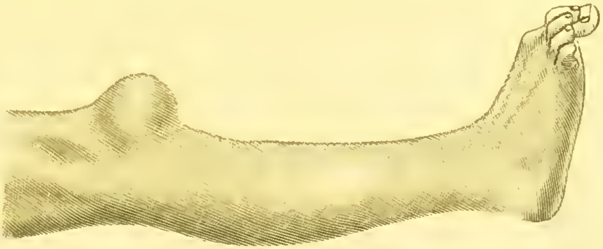

FIG. 77.—Hydrops of Prepatellar Bursa in a housemaid.

Of the numerous bursæ in the popliteal space, that between the *semi-membranosus* and inner head of the gastrocnemius is most frequently enlarged (Fig. 78). It is usually of the nature of a simple hydrops, forming a fluctuating egg- or sausage-shaped swelling at the inner side of the popliteal space. It is flaccid in the flexed, and tense in the extended position of the limb. As a rule it causes little inconvenience and may be left alone. Otherwise it should be dissected out, and if there is a communication with the knee-joint this should be closed with sutures. An adventitious bursa may form over the *external malleolus*, especially in tailors, giving rise to the condition known as "tailor's ankle" (Fig. 79). The bursa between *the tendo Achillis and the upper part of the os calcis* may become inflamed

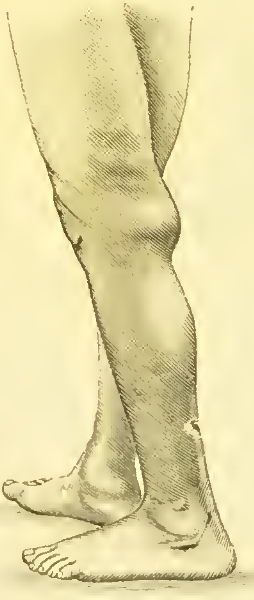

FIG. 78.—Enlarged Semi-Membranosus Bursa.

—especially as a result of post-scarlatinal rheumatism or gonorrhœa. The affection is known as Achillo-bursitis. There is severe pain in the region of the insertion of the tendo Achillis, and the movements at the ankle-joint are restricted. The patient is lame, and may be unable to walk when the feet are bare. A tender swelling forms on either side of the tendon. When, in spite of palliative treatment, the affection persists or relapses, it is best to excise the bursa. A flap of skin is raised from the posterior aspect of the heel, the tendo Achillis is split longitudinally, and the bursa dissected out. If there is a bony projection from the os calcis, as sometimes occurs, it should be shaved off with the chisel.

Sometimes there is a bursa on the under aspect of the os calcis—*the subcalcanean bursa*—which, when inflamed, gives rise to marked local pain and tenderness in the sole of the foot. This affection may be associated with a spinous projection from the bone, which may be seen in a skiagram.

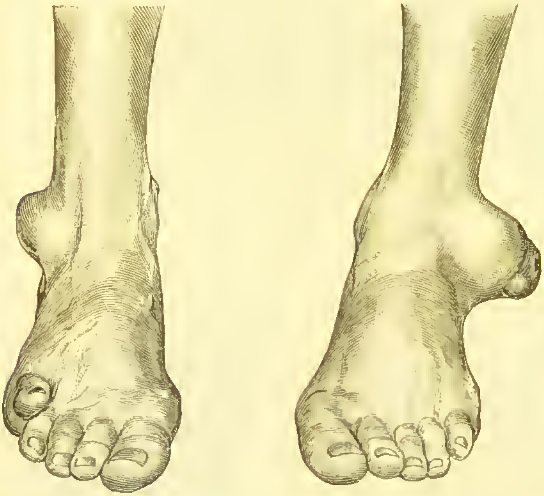

FIG. 79.—Gouty Disease of Bursæ in a tailor. The bursal tumours were almost entirely composed of urate of soda.

The enlargement of adventitious bursæ over the head of the first metatarsal in hallux valgus (*bunion*); over the tarsus, metatarsus, and digits in the different forms of club-foot; over the angular projection in Pott's disease of the spine; over the end of the bone in amputation stumps, and over hard tumours such as chondroma and osteoma,—are described elsewhere.

CHAPTER XX.

INJURIES OF BONES.

Contusions—Wounds—FRACTURES: *Pathological; Traumatic; Varieties* —Simple fractures—Compound fractures—SEPARATION OF EPIPHYSES—Repair of fractures—Interference with repair.

THE injuries to which a bone is liable are Contusions, Open Wounds, and Fractures.

Contusions of Bone are almost of necessity associated clinically with similar injuries of the overlying soft parts. The mildest degree consists in a bruising of the periosteum, which is raised from the bone by an effusion of blood, constituting a *hæmatoma of the periosteum.* This may be rapidly and completely absorbed, or it may give place to a thickening of the bone (*traumatic node*), which may persist for a long time and be attended with deep-seated pain. In more severe cases the osseous tissue is compressed or even splintered, and blood is effused into the cancellated tissue or medullary cavity. Tendons or ligaments may be stretched or partially torn from their attachments to bone, leading to an effusion of blood, which may ultimately be replaced by newly formed osseous tissue.

Contusions of bone may play a part in the etiology of acute osteo-myelitis and of tuberculosis, by furnishing an area of depressed tissue for the lodgment of bacteria circulating in the blood. It has been sometimes alleged that atrophy with shortening may follow contusions of bone in old people—as, for example, in the neck of the femur, but there is reason to doubt this.

Treatment.—Rest, elevation, the application of lead and opium or carbolic fomentations, or of an ice-bag, constitute the best methods of treatment. Massage and the internal administration of potassium iodide favour the absorption of effusions and nodes.

When the skin is broken the condition approaches that of a compound fracture, and is treated on the same lines.

Open Wounds of Bone of the incised and contused varieties are usually produced by cuts with sabres, axes, butcher's knives, or scythes, or by circular saws. Punctured wounds are caused by bayonets, arrows, or other pointed instruments. They are all clinically equivalent to compound, incomplete fractures.

FRACTURES.

A fracture may be defined as a sudden and violent solution in the continuity of a bone.

Pathological or Spontaneous Fractures.

A pathological or spontaneous fracture has as its primary cause some definite pathological state of the bone, which permits of its giving way on the application of a force which would be quite insufficient to break a healthy bone. In many cases the force which happens to be applied merely hastens its complete severance. The following conditions may be mentioned as predisposing to pathological fracture.

Atrophy of bone may proceed to such an extent in old people, or in those who for long periods have been bed-ridden, that the slightest violence suffices to determine a fracture. This most frequently occurs in the neck of the femur in old women, the mere exertion of turning in bed being sometimes sufficient to cause the break. Atrophy from the pressure of an aneurysm or a simple tumour may erode the whole thickness of a bone, or may thin it out to such an extent that very slight force is sufficient to break it. In general paralytics, and in patients in the advanced stages of locomotor ataxia and other chronic diseases of the nervous system, an eccentric atrophy of all the bones sometimes takes place, and may proceed so far that multiple fractures are induced by trifling causes. They occur painlessly, most frequently in the ribs or long bones of the limbs, and usually unite satisfactorily, although with an excessive amount of callus. Attendants and nurses must be warned against using force in handling such patients, as otherwise they may be unfairly blamed for causing these fractures.

Fragilitas ossium is the name applied to a condition, often hereditary, and frequently met with in infants, in which all the bones of the body are excessively fragile, and favour the occurrence of multiple fractures, which usually heal with considerable deformity. *Rickets* and *scurvy* may be attended with a similar fragility of the bones. In the early stages of *osteomalacia*, while the bones still contain some mineral matter, fractures are readily produced; but later, when they have become completely decalcified, the bones simply bend.

Osteo-myelitis, tuberculous and syphilitic disease, and certain *tumours*, especially those which grow in the interior of bones, may predispose to fracture. Indeed, it is not unusual for the sudden breaking of the bone to be the first intimation of the existence of a tumour.

Intra-uterine fractures and fractures occurring *during birth* are usually associated with some form of external violence, but it is believed that in the majority of cases the fœtus is the subject of some constitutional disease, such as rickets or syphilis, which weakens the bones.

TRAUMATIC FRACTURES.

Traumatic fractures are usually the result of a severe force acting from without, although sometimes they are produced by powerful muscular contraction.

When the bone gives way at the point of impact of the force, the violence is said to be *direct*, and a "fracture by compression" results, the line of fracture being as a rule transverse. The soft parts overlying the fracture are more or less damaged according to the weight and shape of the impinging body. Fracture of both bones of the leg from the passage of a wheel over the limb, fracture of the shaft of the ulna in warding off a stroke aimed at the head, and fracture of a rib from a kick, are common illustrative examples of fractures by direct violence.

When the force is transmitted to the seat of fracture from a distance, the violence is said to be *indirect*, and the bone is broken by "torsion" or by "bending." In such cases the bone gives way at its weakest point, and the line of fracture tends to be oblique. Thus both bones of the leg are frequently broken by a person jumping from a height and landing on the feet, the tibia breaking in its lower third, and the fibula at a higher level. Fracture of the clavicle in its middle third, or of the radius at its lower end, from a fall on the outstretched hand, are common accidents produced by indirect violence. The ribs also may be broken by indirect violence, as when the chest is crushed antero-posteriorly, the bones bending beyond the limits of their elasticity, and giving way near their angles. In such fractures the soft parts do not suffer by the violence causing the fracture, but they may be injured by displacement of the fragments.

In fractures by *muscular action* the bone is broken by "traction" or "tearing." The sudden and violent contraction of a muscle may tear off an epiphysis, such as the head of the fibula, the anterior-superior iliac spine, or the coronoid process of the ulna; or a bony process may be separated, as, for example, the tuberosity of the os calcis, the coracoid process of the scapula, or the greater tuberosity of the humerus. Long bones also may be broken by muscular action. The clavicle has snapped across during the act of swinging a stick, the humerus in throwing a stone, and the femur when a kick has missed its object. Fractures of ribs have occurred during fits of coughing or in the violent efforts of parturition.

Before concluding that a given fracture is the result of muscular action alone, it is necessary to exclude the coexistence of any of the conditions which lead to pathological or spontaneous fracture.

Although the force acting upon the bone is the primary factor in the production of fractures, there are others to be considered. Thus the age of the patient is of importance. During infancy and early childhood fractures are less common than at any other period of life, and are usually transverse, incomplete, and of the nature of bends. During adult life, especially between the ages of thirty and forty, the frequency of fractures reaches its maximum. In aged persons, although the bones become more brittle, by the marrow spaces in their interior becoming larger and filled with fat, fractures are less frequent, doubtless because the old are less exposed to such violence as is likely to produce fracture.

Males, from the nature of their occupations and recreations, sustain fractures much more frequently than do females, except in extreme old age, when the opposite is the case.

A liability to fracture is often hereditary, members of certain families showing a marked predisposition to this form of injury.

Bennett of Dublin has drawn attention to the fact that the characters of a given fracture may be inferred from a consideration of—(1) the shape and structure of the affected bone, and (2) the nature of the fracturing force. As there is great uniformity in the shape, construction, and relative strength of a particular bone in different subjects, and as each part of any particular bone is liable to the same kinds and degrees of external violence or muscular strain, it follows that individual fractures conform more or less closely to a particular type. Thus the "typical fracture" of the clavicle resulting from indirect violence occurs in the middle third of the bone and is oblique (Fig. 87); while direct violence generally produces a transverse fracture near the outer end of the bone. The typical fracture of the bones of the leg caused by direct force is transverse, and occurs in the lower third; while indirect violence produces an oblique fracture of the tibia low down, and of the fibula higher up (Fig. 166).

Clinical Varieties of Fractures.—The most important subdivision of fractures is that into simple and compound.

In a *simple* or subcutaneous fracture there is no communication, directly or indirectly, between the broken ends of the bone and the external air. In a *compound* or open fracture, on the other hand, such a communication exists, and, by furnishing a means of entrance for bacteria, adds materially to the gravity of the injury.

A simple fracture may be complicated by the existence of a wound of the soft parts, which, however, does not actually communicate with the broken bone.

Fractures, whether simple or compound, fall into other clinical groups, according to (1) the degree of damage done to the bone, (2) the direction of the break, and (3) the relative position of the fragments.

(1) *According to the Degree of Damage done to the Bone.*—Thus a fracture may be incomplete—for example, in *greenstick fractures* which occur only in young persons—usually below the age of twelve—while the bones are still soft and flexible. They result from forcible bending of the bone, the osseous tissue on the convexity of the curve giving way, while that on the concavity is compressed. The clavicle, radius, and ulna are the bones which most frequently suffer in this way (Fig. 119). *Fissures* may occur on the flat bones of the skull, the pelvic bones, or the scapula; or in association with other fractures in long bones (Fig. 82), when they often run into joint surfaces. Clinically they can only be recognised when compound. *Depressions* or indentations sometimes occur on long bones, but are more common in the bones of the skull.

The fractured portion of bone may be broken up into several pieces, constituting a *comminuted* fracture. This usually results from severe degrees of direct violence, such as are sustained in railway or machinery accidents, from gunshot wounds, or from very forcible bending.

Sub-periosteal fractures are those in which, although the bone is completely broken across, the periosteum remains intact. These are especially common in children, and as the thick periosteum prevents displacement, the existence of a fracture may be overlooked, even in such a bone as the femur.

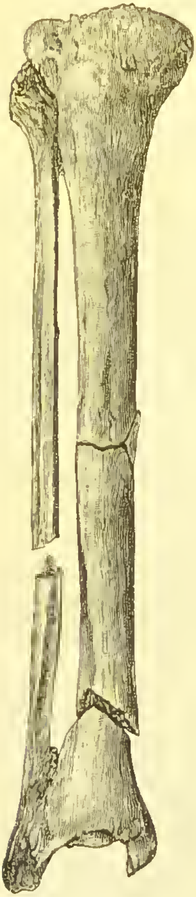

FIG. 80.—Multiple Fracture of Tibia and Oblique Fracture of Fibula, the result of a cable-car accident.

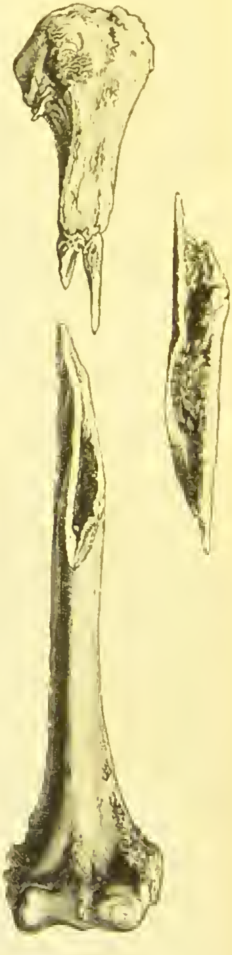

FIG. 81.—Spiral Fracture of Humerus.

A bone may be broken at several places, constituting a *multiple* fracture (Fig. 80).

Separation of bony processes, such as the coracoid process, the epicondyle of the humerus, or the tuberosity of the os calcis, may result from muscular action or from direct violence. *Separation of epiphyses* will be considered later.

(2) *According to the Direction of the Break.*—*Transverse* fractures are those in which the bone gives way more or less exactly at right angles to its long axis. These usually result from direct violence or from end to end pressure. *Longitudinal* fractures extending the greater part of the length of a long bone are exceedingly rare. *Oblique* fractures are very common, and result usually from indirect violence, bending, or torsion (Figs. 82, 83). *Spiral* fractures result from forcible torsion of a long bone, and are met with most frequently in the tibia, femur, and humerus (Fig. 81).

(3) *According to the Relative Position of the Fragments.*—The bone may be completely broken across, yet its ends remain in apposition, in which case there is said to be *no displacement.*

There may be an *angular* displacement—for example, in greenstick fracture; or the ends may *overlap* one another, although they do not completely part company. In transverse fractures of the patella or of the olecranon there is often *distraction* or pulling apart of the fragments (Fig. 161). The broken ends, especially in oblique fractures, may *override* one another, and so give rise to shortening of the limb. Where one fragment is acted upon by powerful muscles a *rotatory* displacement may take place, as in fracture of the radius above the insertion of the pronator radii teres, or of the femur just below the small trochanter. The fragments may be *depressed*, as in the flat bones of the skull or the nasal bones. At the cancellated ends of long bones, particularly the upper end of the femur and humerus, and the lower end of the radius, it is not uncommon for one fragment to be *impacted* or wedged into the substance of the other (Fig. 143).

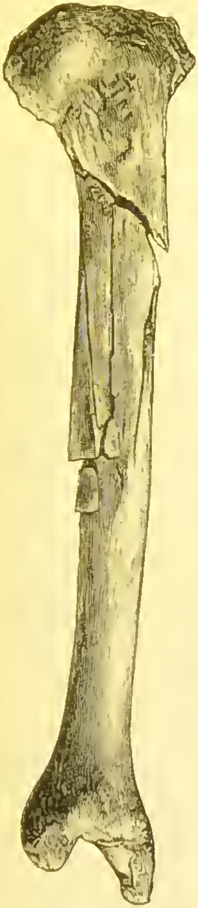

Fig. 82. — Oblique Fracture of Upper Third of Tibia with Fissuring of Lower Fragment. Limb run over by a railway waggon.

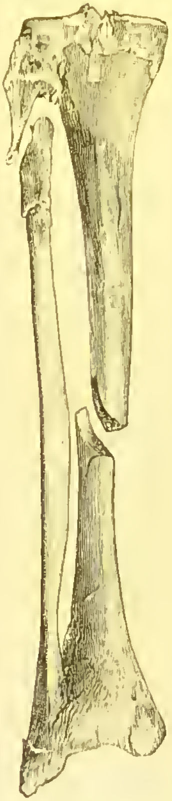

Fig. 83. — Showing (1) Oblique Fracture of Tibia; (2) Oblique Fracture with partial Separation of Epiphysis of Upper End of Fibula; (3) Incomplete Fracture of Fibula in Upper Third. Result of railway accident. Boy æt. 16.

Causes of Displacement.—The factors which influence displacement are chiefly mechanical in their action. Thus the direction and nature of the fracture play an important part. Transverse fractures with roughly serrated ends are less liable to displacement than those which are oblique with more or less smooth surfaces. The direction of the causal force also is a dominant factor in determining the direction in which one or both of the fragments will be displaced. Gravity, acting chiefly upon the distal fragment, also plays a part in determining the displacement—for example, in fractures of the thigh or of the bones of the leg—where the lower segment of the limb rolls outwards (Fig. 142), and in fractures of the shaft of the clavicle where the weight of the arm carries the shoulder downwards, forwards, and inwards (Fig. 88). After the break has taken place and the causal force has ceased to act, displacement may be produced by the rough handling of those who render first aid, the careless or improper application of splints or bandages, or by the weight of the bedclothes.

In certain situations the contraction of unopposed, or of unequally opposed, groups of muscles plays an important part in determining the displacement. For example, the ilio-psoas tends to tilt the upper fragment forward and outward in fracture immediately below the lesser trochanter of the femur (Fig. 148), the muscles of the calf pull the lower fragment back towards the popliteal space in supra-condylar fracture of the femur, and the muscles inserted into the bicipital groove adduct the upper fragment in fracture of the humerus above the deltoid insertion.

Clinical Features of Simple Fractures.—In the first place, the *history of the accident* should be carefully investigated, special attention being paid to the nature of the violence—whether a blow, a twist, a wrench, or a crush, and whether the violence was directly or indirectly applied. The degree of the violence may often be judged approximately from the instrument inflicting it—whether, for example, a fist, a stick, a cart wheel, or a piece of heavy machinery. The position of the limb at the time of the injury; whether the muscles were braced to meet the blow or were lax and taken unawares; and the patient's sensations at the moment, such as his feeling something snap or tear, may all furnish useful information.

Signs of Fracture.—The most characteristic signs of fracture are unnatural mobility, deformity, and crepitus.

Unnatural mobility—that is, movement between two segments of a limb at a place where movement does not normally occur—may be evident when the patient makes attempts to use his limb, or may only be elicited when the fragments are seized and moved in opposite directions or rotated. *Deformity*, or the part being "out of drawing" in comparison with the normal side (Figs. 167 and 170), varies with the site and direction of the break, and depends upon the degree of displacement between the fragments. *Crepitus* is the name applied to the peculiar grating or clicking which may be heard or felt when the fractured surfaces are rubbed against one another.

The presence of these three signs in association is sufficient to prove the existence of a fracture, but the absence of one or more of them does not negative this diagnosis. There are certain fallacies to be guarded against. For example, a fracture may exist and yet unnatural mobility may not be present, because the bones are impacted into one another, or because the fracture is an incomplete one. Again, the extreme tension of the swollen soft tissues overlying the fracture may prevent the recognition of movement between the fragments. Deformity also may be wanting under various conditions—as, for instance, when there is no displacement of the fragments. Similarly, crepitus may be absent when impaction exists, when the fragments completely override one another, or are separated by an interval, or when soft tissues, such as torn periosteum or muscle, are interposed between them. A sensation closely resembling crepitus may be felt over a large extravasation of blood, over effusions into tendon sheaths, and over joints in certain chronic diseases. The rubbing of the dislocated end of a bone against the fibrous tissues amongst which it lies, and the crackling of air in subcutaneous emphysema, also closely simulate the crepitus of fracture.

It is not advisable to be very diligent in eliciting these signs at the bedside, partly because of the pain caused by the manipulations, and partly because vigorous handling may do harm by converting a simple into a compound fracture, by undoing impaction, or by producing displacement which does not already exist.

It is often necessary for purposes of diagnosis to administer a general anæsthetic, particularly in injuries of deeply placed bones and in the vicinity of joints. Before doing so, the appliances necessary for the treatment of the injury should be made ready, in order that the fracture may be reduced and set before the patient regains consciousness.

Radiography in the Diagnosis of Fractures.—While radiography is of inestimable value in the diagnosis of many fractures and other injuries, particularly in the vicinity of joints, the student is warned against relying too implicitly on the evidence it seems to afford. No radiogram should be accepted which has not been taken either by or under the direct supervision of a medical man.

A radiogram is not a photograph of the object exposed to the X-rays, but merely a picture of its shadow. As the rays emanate from a single point in the vacuum tube, and as they are not, like the sun's rays, approximately parallel, the shadows they cast are necessarily distorted.

Hence, in interpreting a radiogram, it is necessary to know the relative positions of the point from which the rays proceed, the object exposed, and the photographic plate on which the shadow is registered. The least distortion takes place when the object is in contact with the plate, and the shadow of that part of the object which lies perpendicularly under the light is less distorted than that of the parts lying outside the perpendicular. The light and the plate remaining constant, the amount of distortion varies directly with the distance between the object and the plate.

To ensure accuracy in the diagnosis of fracture by the X-rays, it is necessary to take two views of the limb—one in the sagittal and the other in the coronal plane. By the use of the fluorescent screen, the best positions from which to obtain a clear impression of the fracture may be determined before the radiograms are taken.

Imperfect technique and faulty interpretation of the pictures obtained lead to certain fallacies. In young subjects, for example, epiphysial lines may be mistaken for fractures, or the ossifying centres of epiphyses for separated fragments of bone. The os trigonum tarsi has been mistaken for a fracture of the astragalus. In the vicinity of joints the bones may be crossed by pale bands, due to the light traversing the cavity of the joint. In this way fracture of the olecranon or of the clavicle may be simulated. The neck of the femur may appear to be fractured if a foreshortened view be taken.

It is possible, on the other hand, to overlook a fracture—for example, if there is no displacement, or if the line of fracture is crossed by the shadow of an adjacent bone. In deeply placed bones such as those about the hip, or in bones related to dense, solid viscera,—for example, ribs, sternum, or vertebræ,—it is sometimes impossible to detect evidence of fracture in a radiogram.

It is to be borne in mind also, and especially from the medico-legal point of view, that, as early callus does not cast a shadow in a radiogram, the appearance of fracture may persist long after union has taken place. The disturbed perspective produced by the divergence of the rays may cause the fragments of a united fracture to appear displaced, although in reality they are in good position. If the limb and the plate are not parallel the bones may appear to be distorted, and errors in diagnosis may in this way arise.

As most of the remaining signs are common to all the lesions from which fractures have to be distinguished, their diagnostic value must be very carefully weighed.

Interference with Function.—As a rule, a broken bone is incapable of performing its normal function as a lever or weight-bearer; but when a fracture is incomplete, when the fragments are impacted, or when only one of two parallel bones is broken, this does not necessarily follow. It is no uncommon experience to find a patient walk into hospital with an impacted fracture of the neck of the femur or a complete fracture of the fibula; or to be able to pronate and supinate the forearm in the presence of a greenstick fracture of the radius or with a complete fracture of the ulna.

Pain.—Three forms of pain may be present in fractures: pain as such; pain induced by movement of the limb; and pain elicited on pressure, or "tenderness" (John Duncan). In injuries by direct violence, pain as such is never diagnostic of fracture, as it may be due to bruising or tearing of soft tissues. In the region of a joint also, pain may be due to dislocation or sprain as well as to fracture. In injuries resulting from indirect violence, however, pain localised to a spot at some distance from the point of impact is strongly suggestive of fracture—as, for example, when a patient complains of pain over the clavicle after a fall on the hand, or over the upper end of the fibula after a twist of the ankle. Pain elicited by attempts to move the damaged part, or by applying pressure over the seat of injury, is more significant of fracture. Pain elicited at a particular point on pressing the bone at a distance—for example, pain at the lower end of the fibula on pressing near its neck, or at the angle of a rib on pressing near the sternum—is a valuable diagnostic sign of fracture. When nerve trunks are implicated in the vicinity of a fracture, pain is often present along the course of their distribution.

Localised swelling comes on rapidly, and is due to displacement of the fragments, effusion of blood, and venous and lymphatic congestion.

Discoloration accompanies the swelling, and is often intense and widespread, especially in bones near the surface and when the tension is great. It is not uncommon to find over the ecchymosed area, especially over the shin-bone, large dark blebs containing blood-stained serum. In fractures of deep-seated bones, discoloration may not show on the surface for some days, and then may be at some distance from the break. Alterations in the relative position of *bony landmarks* are valuable diagnostic guides. Alteration in the *length* of the limb, usually in the direction of shortening, is also an important sign. Before drawing deductions care must be taken to place both limbs in the same position and to determine accurately the fixed points for measurement, and also to ascertain if the limbs were previously normal.

Shock is seldom a prominent symptom in uncomplicated fractures, although in old and enfeebled patients it may be serious and even fatal. During the first two or three days after a fracture there is almost invariably some degree of traumatic *fever*, indicated by a rise of temperature to 99° or 100° F. (Fig. 8).

Complications. *Progressive debility* is usually observed in old people who are confined to bed as a result of a fracture, even although repair is going on satisfactorily. The appetite is lost, the vital reactions are diminished, and the mental condition often deteriorates. *Fat embolism* sometimes occurs, and *delirium tremens* is a not infrequent accompaniment of fractures in persons addicted to alcohol.

Injuries to large arteries are not common in simple fractures. The femoral, popliteal and tibial arteries, however, are liable to be compressed, punctured, or torn across in fractures of the bones with which they lie in close contact. Thrombosis, traumatic aneurysm, or gangrene may follow such injuries. Large *veins* are even less frequently injured, probably because of their soft, lax walls and the low tension of the blood in them. Venous thrombosis, leading to pulmonary embolism, is the great risk attending this complication, although gangrene is also to be feared.

Injuries to nerve trunks are comparatively common, especially in fractures of the upper arm, where the musculo-spiral, ulnar, or other branches of the brachial plexus are liable to suffer; and in fracture of the neck of the fibula, where the external popliteal may be involved.

The nerves may be implicated at the time of the injury, being compressed, bruised, lacerated, or completely torn across by broken fragments, or they may be involved later by becoming compressed by callus. The symptoms depend upon the degree of damage sustained by the nerve, and vary from partial and temporary interference with sensation and motion to complete and permanent abrogation of function.

Suppuration and necrosis are exceedingly rare sequelæ of simple fractures, and are due to bacterial infection through the blood-stream, or to organisms already located in the damaged area.

Prognosis in Simple Fractures.—Danger to life in simple fractures depends chiefly on the occurrence of complications. In old people where the injury necessitates long and continuous lying on the back, bronchitis, hypostatic pneumonia, and bed-sores are prone to occur. Gradually increasing debility is also a cause for anxiety in these cases. Fractures complicated with injury to internal organs, and fractures where gangrene threatens, are, of course, of grave import.

The prognosis as regards the function of the limb should always be guarded, even in simple fractures. Incidental complications are constantly liable to arise, delaying recovery and preventing a satisfactory result, and these not only lead to disappointment, but may even form a ground for actions for malpraxis.

The character, direction, and extent of the fracture influence the prognosis, the best results usually following single and transverse breaks, while those which are multiple, comminuted, or oblique unite less rapidly and satisfactorily.

Fibrous union is a common result in fractures of the neck of the femur in very old people. A similar result may follow at any age in fracture of the patella, of the olecranon, coronoid, and coracoid processes—a prospect of which the patient should be duly warned.

Impairment of growth and eventual shortening of the limb may result from involvement of an epiphysis in young persons (Fig. 105).

Stiffness of joints is liable to follow fractures implicating articular surfaces, or to result from chronic arthritic changes occurring during the period the limb is confined in splints.

True osseous ankylosis is not a common sequel of simple fractures, but locking of joints from the mechanical impediment produced by the union of imperfectly reduced fragments, or from masses of callus, is not uncommon, especially in the region of the elbow.

Wasting of the muscles from disuse, and œdema of the limb, which is slow to disappear, often delay the complete restoration to usefulness. Delayed union, want of union, and the formation of false joints will be referred to later.

Treatment.—It may be accepted as an axiom in the treatment of fractures that the earlier it is begun the better. Immediately after the accident the muscles offer less resistance to the replacement of the fragments than they do after having for some time been irritated into contraction by the pressure of rough bony spicules. The swelling of the soft tissues, due to effusion of blood and serum, is also less; and time has not permitted of adhesions forming between torn tissues, or the organisation of effused products.

Without entering into the question of first aid in cases of fracture, it may be said that every care must be taken during the transport of the patient that no further damage is done to the broken limb. To this end the part must be secured in the best form of extemporised splint which the ingenuity of the surgeon and the surroundings of the patient can furnish, the apparatus being so designed as to control not only the broken fragments, but also the joints above and below the fracture.

When the ordinary method of removing the clothes involves any risk of unduly moving the injured part, they should be slit open along the seams.

The patient should be placed on a firm straw, horse-hair, or spring mattress, stiffened in the case of fractures of the spine, pelvis, or lower limbs, by strong wooden fracture-boards inserted between the mattress and the frame of the bed. Special mattresses constructed in four pieces, to facilitate the nursing of the patient, are sometimes used. Feather beds are to be avoided as utterly unsuitable in the treatment of fractures.

In many cases, particularly in very muscular subjects, in restless alcoholic patients, and in those who do not bear pain well, a general anæsthetic is a valuable aid to the rapid and accurate setting of a fracture, as well as a means of rendering the diagnosis more certain.

The procedure popularly known as "setting a fracture" consists in restoring the displaced parts to their normal position, and is spoken of technically as the *reduction* of the fracture. After reduction has been effected appropriate means must be taken to retain the parts in position.

The Reduction of a Fracture.—In some cases the displacement may be completely overcome by relaxing the muscles acting upon the fragments. In most cases, however, it is necessary, after relaxing the muscles, to employ *extension*, by making forcible but steady traction on the distal fragment, while *counter-extension* is exerted on the proximal one, either by an assistant pulling upon that portion of the limb, or by the weight of the patient's body. The fragments having been freed, and any shortening of the limb corrected in this way, the broken ends are moulded into position—a process termed *coaptation*.

The reduction of a recent greenstick fracture consists in forcibly straightening the bend in the bone. In greenstick fractures which have been left for some time unreduced, so long as the deformity is moderate in degree no active treatment is necessary, as there is a tendency for the bone gradually to become straight as it grows. When the deformity is excessive, however, it is necessary to correct it by rebending, or, if necessary, breaking or dividing the bone and resetting it.

In certain cases of impacted fracture, which will be specified later, it is not advisable to undo the impaction.

In selecting a means of retaining a fracture in position after its reduction, the various factors which tend to bring about re-displacement must be taken into consideration, and appropriate measures adopted to counteract each of these. Thus it may be that the fragments, being oblique, tend to glide past one another ; that powerful muscles inserted into one of the fragments pull it away from its neighbour; that the weight of the distal portion of the limb causes it to fall in a particular direction in obedience to gravity; or that certain movements on the part of the patient determine displacement.

In addition to retaining the broken ends of the bone in apposition, the after treatment of a fracture involves the taking of steps to promote the absorption of effused blood and serum, to maintain the circulation through the injured parts, and to favour the repair of damaged muscles and other soft tissues. Means must also be taken to maintain the functional activity of the muscles of the damaged area, to prevent the formation of adhesions in joints and tendon sheaths, and generally to restore the function of the injured part.

Practical Means of Effecting Retention—By Position.—It is often found that only in one particular position can the fragments be made to meet and remain in apposition—for example, the completely supine position of the forearm in fracture of the radius just above the insertion of the pronator radii teres. Again, in certain cases it is only by relaxing particular groups of muscles that the displacement can be undone—as, for instance, in fracture of the femur immediately above the condyles, where flexion of the knee, by relaxing the calf muscles, permits of reduction.

Massage and Movement in the Treatment of Simple Fractures.—Until within recent years fractures were invariably treated by complete immobilisation of the injured limb in a splint or other form of rigid apparatus, until firm osseous union had taken place. The result of the prolonged fixation of the limb was that in many cases the muscles became atrophied from want of use, adhesions formed in joints and tendon sheaths from organisation of effused products, the restoration of function was much delayed, and in some cases permanent stiffness resulted.

Lucas-Championnière, in 1895, was the first to advocate the treatment of fractures by massage and movement, and to discard the use of rigid splints and other retentive appliances, and since then many surgeons have followed his teaching. From experience of this method we are satisfied that it has many advantages over the older plan. At the same time, it involves an amount of direct and personal supervision which is not at all times practicable.

The measures adopted vary according to the nature and seat of the fracture, but in general terms it may be stated that after the fracture has been reduced, the ends of the broken bone are carefully retained in position by the hands of an assistant, and gentle massage is applied by the surgeon. The parts on the proximal side of the injured area are first gently stroked upwards to empty the veins and lymphatics, and to disperse the effused blood and serum. The rubbing process is then applied to the swollen area, and gradually extended down over the seat of the fracture and into the parts beyond. In this way the circulation through the damaged segment of the limb is improved, the veins are emptied of blood, and the removal of effused fluids is stimulated. The neighbouring joints are gently moved, and the patient is encouraged to contract the muscles voluntarily, care being taken all the while that the broken ends of the bone are not displaced. After the rubbing has been continued for from fifteen to twenty minutes, the limb is placed in a comfortable position, and retained there by pillows, sand-bags, or, if found more convenient, by a light form of movable splint. In fixing the limb in position it is necessary to avoid constricting it in any way that will interfere with the circulation.

The massage is repeated every day, the sittings being gradually extended to twenty or thirty minutes, while the rubbing and the movements are carried out more energetically as time proceeds. The patient is encouraged at each sitting to move his joints voluntarily and against resistance. After an interval varying with the nature of the fracture all retentive appliances may be removed, but the massage should be continued until consolidation of the callus is complete.

The value of this procedure is greatest in fractures in the vicinity of joints, particularly the elbow, ankle, wrist, and knee. Not only is pain diminished, the formation of bony callus promoted and union thereby hastened, but the prolonged crippling stiffness which so often follows after immobilisation in splints is avoided by the dispersion of effusion and œdema and the prevention of adhesions. The risk of redisplacement of fragments is exceedingly slight, and is only to be feared in oblique fractures in the shafts of long bones, such as the humerus, femur, or bones of the leg; but even in these situations, by careful fixation of the broken ends while the massage and movements are being carried on, any such ill effects can usually be obviated. Want of union, so far from being a special risk attending this method of treatment, is less liable to occur, if ordinary precautions be taken, than when splints alone are employed.

Splints and other Appliances.—The less complicated and specialised splints are the better. The appropriate splints for individual fractures and the method of applying them will be discussed later; but it may here be said that the general principle is that when dealing with a part where there is a single bone, as the thigh or upper arm, the splint should be applied in the form of a *ferrule* to surround the break; whereas in situations where there are two or more parallel bones, as in the forearm, leg, metatarsus, or metacarpus, the splint should take the form of a *box* (Fig. 84).

Simple wooden splints of plain deal board or yellow pine, sawn to the appropriate length and width; or *Gooch's splinting*, which consists of long strips of soft wood, glued to a backing of wash leather, are the most useful materials for splints. Gooch's splinting has the special advantage that when applied with the leather side next the limb it encircles the part as a ferrule; while it remains rigid when the wooden side is turned towards the skin (Fig. 84). Perforated sheet lead or tin, stiff wire netting, and hoop iron also form useful splints.

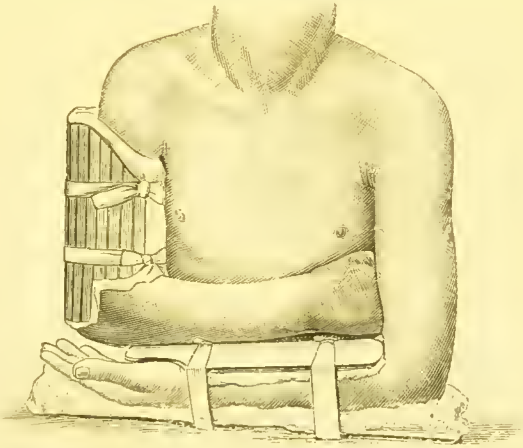

FIG. 84.—Gooch Splint applied as a "Ferrule" on Right Upper Arm, as a "Box" on Left Forearm.

When it is desirable that the splint should take the shape of the part accurately, a plastic material may be employed. Perhaps the most convenient is *poroplastic felt*, which consists of strong felt saturated with resin. When heated before a strong fire, or when placed in boiling water, it becomes quite plastic, and may be accurately moulded to any part, and on cooling again becomes rigid. The splint should be cut from a carefully fitted paper pattern. Millboard, leather, or gutta-percha softened in hot water, and moulded to the part, may also be employed.

In military practice in the field, and in other conditions where treatment by massage and movement is impracticable, and where movable splints are inconvenient, splints of *plaster of Paris*, *starch*, or *water-glass* are sometimes used, especially in the treatment of fractures of the leg. When employed in the form of an immovable case they are open to certain objections — for example, if applied immediately after the accident they are apt to become too tight if swelling occurs; and if applied while swelling is still present, they become slack when this subsides, so that displacement is liable to occur.

When it is desired to enclose the limb in a plaster case, coarse muslin bandages, three yards long, and charged with the finest quality of thoroughly dried plaster of Paris, are employed. A boracic lint bandage is evenly applied next the skin, and the bony prominences are specially padded. The plaster bandage is then placed in cold water till it is thoroughly saturated, and after the excess of water is squeezed out of it, is applied in the usual way from below upward. From six to ten plies of the bandage are required. In the course of half-an-hour the plaster should be thoroughly set. A plaster case can be readily removed after immersion for a short time in water.

Croft's splint, or some modification of it, is perhaps the best form of movable plaster splint. It is made by accurately shaping *two* pieces of thoroughly shrunk house-flannel to *each* side of the limb, and immersing one of each pair in a solution of plaster of Paris of the consistence of thin cream, till the flannel is thoroughly impregnated. The dry pieces are placed next the skin, with the saturated pieces over them, and a coarse gauze bandage is then applied to fix them in position. After the plaster has set, if it is desired to remove the splint for the purpose of employing massage, the gauze bandage is cut along the front of the limb, and the splint opened out on the hinge formed by the posterior turns of the bandage.

A splint similar to Croft's, but much lighter, may be made of poroplastic felt fixed in position with an elastic webbing bandage. Formerly starch bandages were employed in place of the elastic bandage.

Padding is an essential adjunct to all forms of splints. The whole part enclosed in the splint must be covered with a thick layer of soft and elastic material, such as cotton wool or lint. All hollows should be filled up, and all bony projections especially protected by rings of wadding so arranged as to take the pressure off the prominent point and distribute it on the surrounding parts. Opposing skin surfaces must always be separated by a layer of absorbent wool or boracic lint. A bandage should never be applied to the limb underneath the splints and pads, as congestion or even gangrene may be induced thereby.

Operative Treatment of Simple Fractures.—In certain cases of simple fracture it is found impossible to bring the fragments into accurate apposition or to retain them there. This may be due to the obliquity of the fracture—as, for example, in the bones of the leg; to the interlocking of fragments, as occurs frequently in epiphysial separations; to the traction of powerful muscles on one of the fragments, as in fracture of the patella or olecranon; or to the interposition of soft tissues between the broken ends. Under such circumstances it may be necessary to expose the fracture by operation, and after reducing it, to fix the fragments together by wires, pegs, or screws. Such operations, however, are not to be undertaken lightly. They are often difficult, and if septic infection takes place the results may be disastrous.

COMPOUND FRACTURES.

We have already seen that the characteristic feature of a compound fracture is the existence of an open wound leading down to the break in the bone. The wound may vary in size from a mere puncture to an extensive ragged tear of all the soft parts. In other particulars, such as the degree of damage to the bone, the direction of the break, and the relative position of the fragments, simple and compound fractures agree. It is the presence of the wound which, by providing a means of entrance for bacteria and conditions favourable to their growth and development, dominates the whole aspect of the case.

A fracture may be rendered compound *from without*, the soft parts being damaged by the same object which breaks the bone —as, for example, a cart wheel, a heavy piece of machinery, or a bullet. Sloughing of soft parts, resulting from the pressure of improperly applied splints, also may convert a simple into a compound fracture. On the other hand, a simple fracture may be rendered compound by agencies acting *from within*—for example, a sharp fragment of bone penetrating the skin, or the sloughing of the skin as a result of extreme tension from effused blood.

As a rule the *diagnosis* is easy, as the bone can either be seen or felt through the wound. When any doubt exists as to whether a wound communicates with the bone or not, it is safer to enlarge it by incision than to assume that the fracture is simple.

The *prognosis* in compound fractures depends, in the first instance, on the success which attends the efforts to make and to keep the wound aseptic, as well as on the extent of damage to the soft tissues and bones. When sepsis ensues in a compound fracture, repair is interfered with, fragments of bone may undergo necrosis and lead to the formation of sinuses, and union is usually attended with excessive and irregular callus formation (Fig. 85).

Treatment.—The leading indication for treatment is to ensure asepsis of the wound. Even in the case of small punctured wounds caused by a pointed fragment coming through the skin, it is never wise to assume that the wound is not infected. It is much safer to enlarge such a wound, pare away the bruised edges, and disinfect the raw surfaces.

In cases of extensive laceration of the soft parts the purification must be methodical and thorough. All soiled, bruised, or torn portions of tissue should be clipped away with scissors, blood-clots removed, and the bleeding arrested by forci-pressure or ligature. When there is good reason to believe that the wound is not already infected, any fragments of bone completely separated from the periosteum may be left; but when there is any suspicion of infection they had better be removed. The wound should then be washed out with sterilised salt solution. On the whole, it is safer not to attempt to obtain primary union by completely closing such wounds, but rather to drain or partially pack them, counter-openings being made at dependent points if necessary.

In other respects the treatment of compound fractures is carried out on the same lines as in simple fractures, provision being made for the dressing of the wound, when this is required, without undue disturbance of the bones. Massage and movement should be commenced as soon as the wound is healed.

Question of Amputation in Compound Fractures.—Before deciding to perform primary amputation of a limb for compound fracture the surgeon must satisfy himself (1) that antiseptic purification is impossible, or, at least, hardly to be expected; (2) that the soft parts are so widely and so grossly damaged that their recovery is improbable; (3) that the vascular and nervous supply of the parts beyond has been rendered insufficient by destruction of the main blood-vessels and nerve trunks; (4) that the bones have been so shattered as to be beyond repair; and (5) that the limb which will be left will be less useful than the stump resulting after a suitable amputation.

In attempting to save the limb of a young subject it is justifiable to run risks which would not be permissible in the case of an older person. To save an upper limb, also, risks may be run which would not be justifiable in the case of a lower limb, because, while a serviceable artificial leg can readily be procured, any portion of the natural hand or arm is infinitely more useful than the best substitute which the instrument-maker can contrive. The risk involved in attempting to save a limb should always be explained to the patient or his friends, in order that they may share the responsibility in case of failure.*

Whether or not the amputation should be performed at once depends upon the general condition of the patient. If the injury is a severe one, and attended with a profound degree of shock, it is better to wait for twenty-four or forty-eight hours. Meanwhile the wound is thoroughly purified, and the limb wrapped in an antiseptic dressing. Means are taken to counteract the shock and to maintain the patient's strength, and evidence of septic infection or of hæmorrhage is carefully watched for. When the shock has passed off and the patient is able to stand the operation, it is then performed under more favourable auspices. Clinical experience proves that by this means the mortality of primary amputations may be materially diminished, especially in injuries necessitating removal of an entire limb.

Having decided to amputate, it is important to do so at such a level as will avoid having bruised, torn, or separated tissues in the flaps, as these are liable to slough or to become the seat of septic infection. In this connection it should be borne in mind that the damage to soft tissues is always wider in extent than appears from external examination.

Amputation may be called for later to arrest spreading septic processes, osteo-myelitis, or gangrene; to prevent exhaustion from prolonged suppuration and septic absorption; or on account of secondary hæmorrhage.

SEPARATION OF EPIPHYSES.

It is only within the last twenty years that the subject of the separation of epiphyses (or, as they are sometimes called, *diastases*[1]) has received its due share of attention, and even yet these injuries are often mistaken for fractures or dislocations.

Surgical Anatomy.—At birth the diaphyses, or shafts of the long bones, are completely ossified, while nearly all the epiphyses are cartilaginous. As ossification begins at different dates, and progresses with varying rapidity in the different epiphyses, the date at which each unites with its diaphysis to form the adult bone also varies.

It is useful to remember that, in the upper extremity, the epiphyses in the regions of the shoulder and wrist, and, in the lower extremity, those in the region of the knee, are the latest to unite; and that it is in these situations that growth in length of the bone goes on longest and most actively. Injuries of these epiphyses, therefore, are most liable to lead to interference with the growth of the limb.

An epiphysis is nourished from the articular arteries and through the vessels of the periosteum covering it.

Pathological Separation of Epiphyses.—There are certain pathological conditions, such as rickets, scurvy, congenital syphilis, tubercle, suppurative conditions, and tumour growths, which render separation of epiphyses liable to occur from injuries altogether insufficient to produce such lesions under normal conditions.

It is interesting to note that the epiphyses are no more liable to be separated in paralytic limbs than in those with a healthy nerve-supply.

Traumatic Separations.—Speaking generally, it may be said that injuries which in an adult would be liable to produce dislocation are in a young person more apt to cause separation of an epiphysis. Indirect violence, especially when exerted in such a way as to combine traction with torsion, is the commonest cause of epiphysial separation. Direct violence is a much less frequent cause. Muscular action occasionally produces separation of such epiphyses as the anterior-superior iliac spine, the lesser trochanter of the femur, or the upper fibular epiphysis.

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[1] The term "diastasis" has been employed in different senses by different writers.

It would appear that the majority of separations take place between the eleventh and the eighteenth years, chiefly because during this period the injuries liable to produce such lesions are most prone to occur. Although easily produced experimentally at earlier ages, they are not often met with clinically. They do not occur after twenty-five, because by that time all the epiphyses have united. In females this form of injury is exceedingly rare, and almost invariably occurs at or before puberty.

The following are the most common seats of separation in the order of their frequency :—(1) The lower end of the femur ; (2) the lower end of the radius ; (3) the upper end of the humerus ; (4) the lower end of the humerus ; (5) the lower end of the tibia ; and (6) the upper end of the tibia.

Morbid Anatomy. — In a true separation the epiphysial cartilage remains attached to the epiphysis. It is only in very young subjects, before ossification of the epiphysis has progressed to any length, that a pure separation between the diaphysis and epiphysis occurs, and even then the separation is seldom complete. In older subjects the common lesion is a separation along part of the epiphysial line, with a fracture running into the diaphysis (Fig. 83). It is not uncommon for more than one epiphysis to be separated by the same accident—for example, the lower end of the femur and the upper ends of the tibia and fibula. Like ordinary fractures, epiphysial separations may be *simple* or *compound*. Incomplete separations are liable to be overlooked at the time of the accident, but there is reason to believe that they may form the starting-point of various diseases of bones and joints. Strain of the epiphysial junction is a common injury in young children, and is believed to account for so-called "growing pains" in some cases.

Clinical Features.—In pure and complete separations the symptoms simulate those of dislocation rather than of fracture. Thus, *unnatural mobility* at an epiphysial junction may closely resemble movement at the adjacent joint, especially when the epiphysis is an intracapsular one. The degree of *deformity* is often slight, because of the transverse direction of the lesion, the breadth of the separated surfaces, and the firmness of the periosteal attachment along the epiphysial line. In many cases a distinct, rounded, smooth, and regular ridge, caused by the projection of the diaphysis, can be felt (Fig. 156). The peculiar "muffled" nature of the *crepitus* is one of the most characteristic signs. The older the patient, and the further ossification has progressed, the more does the crepitus resemble that of an ordinary fracture.

Of the subsidiary signs *loss of power* in the limb is one of the most constant; indeed, in young children it is sometimes the first, and may be the only sign which attracts attention. *Pain* and *tenderness* along the epiphysial line are valuable signs, particularly when the lesion is due to indirect or muscular violence and there is no bruising of soft parts. Localised *swelling*, accompanied by *ecchymosis*, is often marked; and the adjacent joint may be distended with fluid.

As distinguishing this injury from a dislocation, it may be noted that in epiphysial separation the shortening is less, there is no jerk felt when the deformity is reduced, the tendency to re-displacement is greater, and the amount of relief given by reduction less than in dislocation. Below the age of twenty a separation is always the more likely injury, as dislocation, except in the elbow, is exceedingly rare before that age.

The Röntgen rays may help to clear up a doubtful diagnosis.

Prognosis and Results.—Reunion in the great majority of cases takes place satisfactorily by the formation of callus in the spongy tissue of the diaphysis and on the inner surface of the periosteum. Non-union is exceedingly rare, if indeed it ever occurs. Deformity and impairment of movement at the adjacent joint may result from imperfect reduction, exuberant callus, or adhesions.

Arrest of growth of the bone is a comparatively rare sequel to a separation which has been properly treated. When it occurs, it is due to diminished action at the epiphysial junction, and not to premature union of the diaphysis with the shaft.

Angular deformity is liable to occur in the leg and forearm, when the growth of one of the bones is arrested after separation of its epiphysis, while the other continues to grow.

Remote complications such as suppuration and tuberculosis are infrequent, and depend upon bacterial infection through the blood-stream.

In spite of the favourable nature of the prognosis in general, the friends of the patient should be warned that a completely satisfactory result cannot always be relied upon.

Treatment.—The general principles which govern the treatment of fractures apply equally to epiphysial separations, and the special points will be described later.

Repair of Injuries of Bone.

The essential steps of the reparative process in fractures, osteotomies, and resections of bone resemble each other so closely that it is convenient to consider them together.

In a *simple fracture* the periosteum and the marrow are usually torn at the same time as the bone is broken. Bleeding therefore occurs around and between the fragments, and a blood-clot is formed. This clot is soon permeated by newly formed blood-vessels, by leucocytes and fibroblasts, the latter being derived from proliferation of the cells of the marrow and periosteum. The granulation tissue thus formed resembles in every particular that described in the repair of other tissues, except that the fibroblasts, being the offspring of cells which normally form bone, assume the functions of *osteoblasts*, and proceed to the formation of new bone. The bone may be formed either by a direct conversion of the fibrous tissue into osseous tissue, the osteoblasts arranging themselves concentrically in the recesses of the capillary loops, and secreting a homogeneous matrix in which lime-salts are speedily deposited; or there may be an intermediate stage of cartilage formation, as occurs so extensively in the normal development of bone in the fœtus.

The newly formed bone is at first arranged in little masses or in the form of rods which unite with each other to form a network of spongy bone, the meshes of which contain marrow. The reparative material, consisting of granulation tissue in the process of conversion into bone is called *callus*, on account of its hard and unyielding character. In a fracture of a long bone, that which surrounds the fragments is called the *external* or *ensheathing callus*, and may be likened to the mass of solder which surrounds the junction of pipes in plumber-work; that which occupies the position of the medullary canal is called the *internal* or *medullary callus;* and that which intervenes between the fragments and maintains the continuity of the cortical compact tissue of the shaft of the original bone is called the *intermediate callus*. This intermediate callus is the only portion of the reparative material which is permanent, the external and internal callus being only temporary, and being reabsorbed through the agency of giant cells as in normal ossification.

Detached fragments or splinters of bone may be incorporated in the callus and made use of in repair, or they may be absorbed.

All surplus bone is removed, the medullary canal is re-formed, the young spongy bone of the intermediate callus becomes more and more compact, and thus the original contour and structure of the bone may be faithfully reproduced.

The amount of callus produced in the repair of a given fracture is greater when movement is permitted between the broken ends. It is also influenced by the character of the bone involved, being less in bones entirely ossified in membrane, such as the flat bones of the skull, than in those primarily ossified in cartilage.

If the fragments are widely separated from one another, or if some tissue, such as muscle, intervenes between them, callus may not be able to bring about a bony union between the fragments, and *non-union* results.

A compound fracture, if not infected by bacteria, heals in the same way as a simple one. Should infection ensue, however, changes associated with inflammation complicate the healing process and give rise to phenomena which will be referred to later. Under these circumstances any fragments which may have been detached are liable to necrose, and require removal.

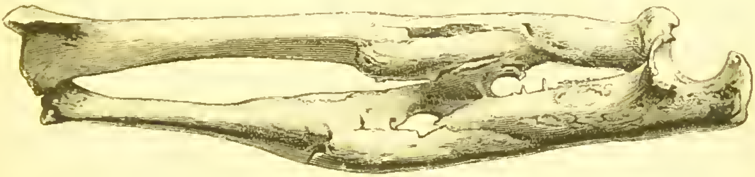

FIG. 85.—Excessive Callus Formation after Septic Compound Fracture of both Bones of Forearm—result of gunshot wound. Fusion of Bones across Interosseous Space.

Modifications of Repair of Fracture.—The normal process of repair by the formation of callus may be interfered with in various ways.

Excess of Callus.—In comminuted fractures, and in those uniting with marked deformity, the amount of callus is in excess, but this is necessary to ensure stability. In other cases, and especially in fractures in the vicinity of large joints, such as the hip or elbow, and sometimes between the bones in fractures of the leg or forearm (Fig. 85), from some undetermined cause the new formation is excessive, and interferes with the usefulness of the limb. Experimental evidence goes to show that the section of nerves induces an excessive formation of callus, and that this callus is very slowly consolidated. Certain nerve trunks, such as the musculo-spiral in the middle of the upper arm, or the ulnar at the elbow-joint, may become included in or pressed upon by callus, and so have their functions interfered with. Such conditions often call for operative interference.

Badly United Fracture—Vicious Union.—Bony union with marked displacement of the fragments is most common in fractures which have not been surgically treated—as, for example, those occurring in sailors at sea; or where the comminution was so great that accurate apposition was rendered impossible. It may also result from imperfect reduction, or because the apparatus employed permitted of secondary displacement. Restlessness on the part of the patient from intractability, delirium tremens, or mania, is the cause of vicious union in some cases.

Whether or not any attempt should be made to improve matters depends largely on the degree of deformity and the amount of interference with function.

While the fracture is still recent, the bone may be bent into position or rebroken under an anæsthetic, and set accurately. When the callus is firmly consolidated, a strong mechanical contrivance, known as an osteoclast, may be employed to rebreak it, but in the majority of cases an osteotomy with chisel and mallet gives results which are more certain and satisfactory. In the milder cases, the bone may be partially divided with an osteotome, then broken across and straightened, as in Macewen's operation for knock-knee; while in those with more marked bending or angling, a wedge may be taken from the convexity, as in the operation for bow-leg. To retain the fragments in position, splints and extension may be employed; or if these measures are insufficient, pegs, screws, bone ferrules, or other direct means may be used.

Defective union may manifest itself in one of three ways: by being delayed; by failing to take place; or by the formation of a false joint between the fragments.

Such errors in repair may be due to constitutional or to local causes. The most potent constitutional cause is general debility. Rickets, scurvy, tuberculosis, and acute infectious diseases also play an important *rôle* in this connection. The influence of syphilis, except in its gummatous forms, in interfering with the union of fractures is doubtful. It is commonly stated that fractures in the aged do not unite as quickly or as certainly as in younger subjects. The influence of old age, however, as a factor in preventing union has been over-estimated; as a matter of fact, most cases of defective union occur in patients of middle age, and one of the most inveterate forms is met with in children.

The most common local cause of non-union is the interposition of portions of muscle, tendon, or other soft tissue between the ends of the bones. This is most liable to occur in oblique fractures with overlapping of the fragments.

Where the fragments are widely separated, as in the patella or olecranon; where a large segment of a bone is shattered and the fragments lost, as in some compound fractures; or where a sequestrum forms between the fragments, osseous union is obviously impossible, and fibrous union all that can be hoped for.

Any interference with the circulation of the limb and any form of bacterial infection leading to suppuration are liable to end in defective union.

Fractures inside the capsule of joints, as in the hip and shoulder, often fail to unite, probably because the short fragment has but a poor vascular supply, and because it is impossible to maintain accurate apposition.

Delayed Union.—The normal period for union of individual bones may be extended from one or other of these causes. At the time when union should be firm and solid it may be found that the fragments are only united by a soft cartilaginous callus, which for a prolonged period may undergo no further change; so that the limb remains incapable of bearing weight or otherwise performing its functions.

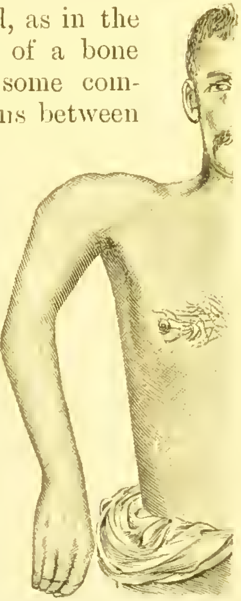

FIG. 86.—Un-united Fracture of Shaft of Humerus following gunshot injury. Patient is attempting to raise the arm from the side.

(Mr. MacGillivray's case.)

Treatment.—In such cases the general condition of the patient should be improved as far as possible by a change to the seaside, careful dieting and tonics. Much benefit often follows the application, above the seat of fracture, of an elastic bandage sufficiently tight to congest the limb beyond (Bier). To concentrate the congestion in the vicinity of the fracture an ordinary bandage should be applied from the distal extremity to within a few inches of the break, and the congestion should be maintained for several hours (six to twelve) daily. When possible an accurately fitting apparatus should be adjusted to enable the patient to get into the fresh air.

Daily massage and the use of a rigid apparatus in the intervals are often beneficial. The injection of oil of turpentine between the fragments has been recommended by Mikulicz; while others favour the forcible rubbing of the ends together, under an anæsthetic if necessary, to promote a plastic reaction in the uniting material. The administration of thyroid extract has been found beneficial in improving the nutrition of the bones in some cases. These methods having failed, the parts may be exposed by incision, and the ends of the bones rawed, and pegged or wired. As a rule satisfactory union is ultimately obtained, although much patience is required.

Want of Union.—In a few cases, without any discoverable cause, union entirely fails to take place. The fragments become atrophied, the ends rounded, and the medullary cavity obliterated, and the ends of the bone remain separate and freely movable. The whole limb may share in this atrophy. In adults this is most frequently met with in the humerus (Fig. 86) and femur, and in most cases union may be brought about by operative measures. In children it is occasionally met with in the bones of the leg, and is seldom, if ever, cured by operation. The lower fragments in these cases become very small and thin, and the limb is so useless that amputation is usually necessary.

Sometimes dense fibrous tissue forms between the fragments, constituting *fibrous union.*

The *treatment* consists in exposing the ends, and after removing any intervening material and rawing their surfaces, inserting nails or wires to secure their apposition. In certain cases dove-tailing the ends into one another, grafting bone, or enclosing the fragments in a ferrule of decalcified bone has been successful.

False Joint.—This is the rarest of all forms of defective union. The ends of the bones become rounded, eburnated, and covered with a layer of cartilage. A firm capsule of fibrous tissue, lined by a layer of endothelium, secreting synovia-like fluid, binds them together and forms a veritable joint.

Treatment is carried out on the same lines as for non-union, the pseudarthrosis being excised before the ends are fixed in apposition.

Absorption of Callus.—From various causes, especially attacks of such diseases as scurvy, pyæmia, or any of the exanthemata, well-formed callus may be softened and absorbed. This may occur weeks, or even months, after union has taken place.

Tumours of Callus.—Tumours, such as chondromata and sarcomata, are liable to occur in callus, or at the seat of old fractures, but the evidence so far is inconclusive as to the causal relationship of the injury to the new growth.

CHAPTER XXI.

INJURIES OF JOINTS.

SURGICAL ANATOMY—INJURIES: *Contusions; Wounds; Sprains; Dislocations*—TRAUMATIC DISLOCATIONS: *Causes; Varieties; Clinical features; Treatment*—Compound dislocations—Old-standing dislocations.

Surgical Anatomy.—The function of a joint is to permit of the movement of one bone upon another. The articular surfaces of the bones are covered with a thin layer of hyaline cartilage, and they are retained in close apposition by the tension of ligaments and of the muscles surrounding the joint. The capsular ligament surrounds the ends of the bones in the form of a tube, and is directly continuous with the periosteum. The capsular ligament is lined by synovial membrane, which at the line of attachment of the capsule is reflected on to the ends of the bones and becomes continuous with the articular cartilage. The common origin of bone, cartilage, periosteum, and synovial membrane from one parent tissue of the embryo, accounts for the readiness with which any one of these tissues may be converted into another under traumatic or pathological influences. The synovial membrane invests intra-articular ligaments, and is projected into the interior of the joint in the form of loose folds wherever the articulating surfaces are not in immediate contact. The surface of the synovial membrane is covered with minute processes or villi, which in diseased conditions may become the seat of hypertrophy. The synovial fluid owes its lubricating quality to mucin, which appears to be derived from the solution of the endothelial cells on the free surface of the membrane. The opposing surfaces of a joint being always in accurate contact, the so-called cavity is only a potential one. If fluid is poured out into the joint, the synovial membrane and capsule are put upon the stretch, causing discomfort or actual pain, which is partly relieved by slightly flexing the joint. If the fluid distension continues, the ligaments elongate and the joint becomes unstable.

Joints derive an abundant blood-supply through the articular arteries. The lymphatics, which take origin in the superficial layers of the synovial membrane, pass to efferent vessels which run in the intermuscular and other connective-tissue planes of the limb. The nerve-supply is chiefly derived from the nerves which supply the muscles acting on the joint and the skin over it.

The injuries to which a joint is liable are Contusions, Wounds, Sprains, and Dislocations.

Contusions of Joints.—Contusion is the mildest form of injury to which a joint is liable. Whether the violence is transmitted from a distance, as in contusion of the hip from a fall on the feet, or acts more directly in the vicinity of the joint, as from a fall on the great trochanter, the main incidence of the force is on the articular surfaces of the bones, which are violently driven against one another. The articular cartilages and the underlying spongy bone, as well as the synovial membrane, are bruised, and there is an effusion of blood and serous fluid into the joint cavity and surrounding tissues.

The most prominent *clinical features* are swelling and discoloration. The swelling, especially in superficially placed joints, is an early and marked symptom, and being mainly due to bleeding into the joint (*hæmarthrosis*), takes the shape of the synovial cavity. In deeply placed joints discoloration may not appear on the surface for some days, especially if the violence has been indirect. The joint is kept in the flexed position, and is only painful when moved. There is no local heat. In hæmophylia considerable effusion of blood into a joint may follow the most trivial injury.

The *prognosis*, as a rule, is good, although a slight degree of effusion into the joint (*hydrarthrosis*) often persists for a time. Tuberculous affections of joints not infrequently date from a contusion. Suppuration is a rare sequel.

Treatment.—When seen immediately after the accident, the best results are obtained by the application of a firm elastic bandage over a thick layer of absorbent wool. After a few hours, massage and movement of the joint are commenced, and systematically and persistently employed. When the effusion is very great and the joint too tense to permit of movement, absorption is often promoted by withdrawing some of the fluid from the joint by means of an aspirating needle. The local application of ice is soothing, but otherwise useless; and prolonged rest only ends in stiffness and impaired or delayed usefulness.

Wounds of Joints.—An accidentally inflicted wound opening into a joint—such, for example, as a stab with a penknife or the point of a railing—is always a serious form of injury, on account of the risk of septic infection giving rise to a generalised purulent arthritis. This is attended with grave danger, not only to the limb, which will be greatly impaired in usefulness, and may even require to be amputated on account of the virulence of the process, but also to the life of the patient from septic absorption, and, it may be, from the subsequent onset of pyæmia.

Penetration of the joint may sometimes be recognised by the escape of synovial fluid from the wound, or by the synovial membrane or articular cartilage being exposed. When doubt exists, the wound should be enlarged. The use of the probe is to be avoided, on account of the risk of carrying septic material from the track of the wound into the cavity of the joint.

Penetrating wounds of joints are treated on the same lines as those associated with compound fractures. After having been thoroughly disinfected, the wound should be drained or treated by the open method, and as soon as it is healed, massage and movement should be employed to prevent the formation of adhesions and consequent stiffness.

Sprains.—A sprain results from a stretching or twisting form of violence which causes movement of the joint beyond its physiological limits, or in some direction for which it is not structurally adapted. The main incidence of the force therefore falls upon the ligaments, which are suddenly stretched or torn, admitting, it may be, of a partial and temporary displacement of the bones. The synovial membrane is also liable to be damaged, and the joint may be filled with blood and serum extravasated from the torn tissues.

Muscles and tendons may be stretched, torn, or dislocated, and their sheaths filled with serous effusion. It is not uncommon for superficial portions of bone to be torn off at the site of attachment of strong ligamentous bands or tendons, constituting a "sprain fracture"; or for intra-articular cartilages to be displaced, as in the knee.

Clinical Features.—The injury is accompanied by intense sickening pain, and this may persist for a considerable time. At first it is aggravated by moving the joint, but if the movement be continued it tends to pass off.

The particular ligaments involved may be recognised by eliciting tenderness on making pressure over them, or by putting them on the stretch by passively moving the joint. In this way a sprain may often be diagnosed from a fracture.

The effusion of blood and serum into the joint and the tissues around it give rise to swelling and discoloration, and there is tenderness on pressing the articular surfaces together. There is no marked elevation of temperature in the affected joint. Fluid effused into tendon sheaths often produces a peculiar creaking, which may be mistaken for the crepitus of fracture. When the swelling is great, it is often necessary to have recourse to the

Röntgen rays to make certain that there is no fracture or dislocation present. Displacement of tendons is apt to be overlooked. In sprains the bony points about the joint retain their normal relations to one another, and usually enable these injuries to be diagnosed from dislocations and, as a rule, from fractures.

Prognosis.—Stiffness, lasting for a longer or shorter time, follows most sprains, but may be largely prevented by proper treatment. In old and rheumatic persons changes of the nature of arthritis deformans are liable to take place, interfering greatly with movement. While suppuration is rare, tuberculous disease not infrequently dates its onset from a sprain.

Treatment.—Sprains are best treated by early massage and movement, combined with firm elastic pressure. In the case of the ankle, for example, massage should be commenced at once, the part being gently stroked upwards. The process is painful for the first few minutes, but soon ceases to be so, and becomes soothing to the patient. The rubbing is continued for from fifteen to twenty minutes, the patient being encouraged to move the toes and ankle. A moderately firm elastic bandage or a few strips of adhesive plaster are then applied, care being taken not to constrict the limb and so interfere with the circulation. The massage is repeated once or twice a day, the sittings lasting for about half an hour. The patient should be encouraged to move the joint from the first, beginning with the movements which put least strain upon the damaged ligaments, and gradually increasing the range. In the course of a few days the patient is encouraged to walk, or cycle, or otherwise to use the joint without subjecting it to strain. Alternate hot and cold douching, followed by massage, is also useful. Complete rest and prolonged immobilisation are only mentioned to be condemned.

In patients predisposed to tuberculosis, however, it is necessary to proceed with greater caution in the employment of massage and exercise.

TRAUMATIC DISLOCATIONS.

A dislocation or luxation is a persistent displacement of the opposing ends of the bones forming a joint. We are here concerned with such dislocations as immediately follow upon injury. Those which are congenital or which result from disease will be studied later.

Sources of Joint Strength.—The capacity of a joint to resist dislocation depends upon (1) the shape of its osseous elements ; (2) the strength and arrangement of its ligaments; (3) the support it receives from muscles or tendons placed in relation to it; and (4) the relative stability of adjacent structures. While all these factors contribute to the strength of a given joint, one or other of them usually predominates, so that certain joints are osseously strong, others are ligamentously strong, while a few depend chiefly upon adjacent muscles for their stability.

The hip and elbow are the best examples of joints deriving their strength mainly from the architectural arrangement of the constituent bones. These joints are dislocated only by extreme degrees of violence, and not infrequently—especially in the elbow—portions of the bones are fractured before the articular surfaces are separated.

The wrist, the carpal, the tarsal, and the clavicular joints, on the other hand, depend for their stability almost entirely on the strength of their ligaments. These joints are rarely dislocated, but as the main incidence of the violence falls on the ligaments they are very frequently sprained. The knee also is a ligamentously strong joint, and is further strengthened by its intra-articular ligaments.

The shoulder is the typical example of a joint depending for its security chiefly upon the muscles and tendons passing over it, and hence the frequency with which it is dislocated. At the same time the great mobility of the scapula and clavicle materially increase the stability of the shoulder-joint. It is probable that the tendons passing in relation to the knee, ankle, and wrist materially add to the stability of these joints.

The proximity of an easily fractured bone also contributes to prevent dislocation of certain joints—for example, fracture of the clavicle prevents an impinging force expending itself on the shoulder-joint; and the frequency of Colles' fracture of the radius, and of Pott's fracture of the fibula, doubtless accounts to some extent for the rarity of dislocation of the wrist and ankle joints respectively. The immunity from dislocation which the joints of young subjects enjoy is partly due to the ease with which the adjacent epiphyses are separated.

The mechanical axiom that "what is gained in movement is lost in stability" is true of joints, those joints which have the widest range of movement being the most frequently dislocated.

Causes.—The majority of dislocations are the result of *indirect* violence, the more movable bone acting as a lever, on a fulcrum furnished by the natural check to movement in the form of ligament, bone, or muscle. In this way most dislocations of the shoulder, hip, and elbow are produced.

At the moment the violence is applied the muscles are relaxed, or otherwise taken at a disadvantage, so that the joint is for the time being deprived of their support. The joint is moved beyond its physiological range, and the end of one of the bones brought to bear upon the ligaments, tears them, and passes through the rent thus made. The muscles then contract reflexly, and pull the head of the bone into an unnatural position outside the capsule. The position assumed will depend upon such factors as the direction of the force, the shape of the joint, the position of the limb at the time of the accident, and the relative strength of the different groups of muscles acting upon the bone which is displaced.

Violence applied *directly* to the joint is a much less frequent cause of dislocation. In this way, however, the knee-joint may be dislocated, one bone being driven past the other—for example, by a kick from a horse; or the acromio-clavicular joint by a blow on the shoulder.

Muscular contraction is not often the sole cause of dislocation, although, as we have seen, it plays an important *rôle* in the production of the majority of these injuries. The shoulder, lower jaw, and patella are, however, not infrequently displaced by muscular action alone. Some acrobats are able to dislocate certain joints by the voluntary contraction of muscles.

Age and Sex.—Dislocations occur most frequently in males during adult life, doubtless on account of the nature of their occupations and recreations. In children the epiphyses are separated, and in old people the bones are broken, by such forms of violence as cause dislocation in adults.

Muscular debility and undue laxness of ligaments resulting from disease or previous dislocation are also predisposing factors.

Clinical Varieties.—The separation between the bones may be *complete* or *partial.* When partial, portions of the articular surfaces remain in apposition, and the injury is known as a *sub-luxation.* Like fractures, dislocations may be *simple* or *compound*, the latter being specially dangerous on account of the risk of septic infection. When seen within a few days of its occurrence, a dislocation is looked upon as *recent;* but when several weeks or months have elapsed, and the rent in the capsule has healed round the neck of the bone, it is spoken of as an *old-standing* dislocation. The latter will call for special mention later.

Dislocations, like fractures, may be *complicated* by injuries to large blood-vessels or nerve trunks, by injuries to internal organs, or by a wound of the soft tissues which does not communicate with the joint. Further, a fracture may coexist with a dislocation.

Clinical Features.—The most characteristic signs of dislocation are *preternatural rigidity*, or want of movement where movement should naturally take place, following immediately on an injury; and *deformity*, the part being "out of drawing" as compared with the uninjured side (Fig. 97). The deformity is characteristic and common to all examples of the same dislocation. The bony landmarks lose their normal relationship to one another. The relationship of the long axis of the bone to the socket is also abnormal.

Although any of the subsidiary signs may occur in lesions other than dislocations, due weight must be given to them in making a diagnosis. *Loss of function* is complete as a rule. *Pain* is much more intense than in fracture, usually because the displaced bone presses upon nerve trunks, and from the same cause there is often numbness and partial paralysis of the limb beyond. *Swelling* of the soft parts due to effused blood is usually less marked in dislocation than in fracture, but is often sufficiently great to interfere with diagnostic manipulations. The displaced head, and sometimes the empty socket, may be palpable. *Discoloration* is usually later of appearing than in fractures. *Alteration in the length* of the injured limb—usually in the direction of shortening—is a very constant feature; while girth measurements commonly show an increase. A peculiar soft *grating* or *creaking sensation* is often felt on attempting to move the joint. This is due to cartilaginous or ligamentous structures rubbing on one another, and must not be mistaken for the crepitus of a fracture. When the dislocation has been reduced, in the great majority of cases, although not in all, the bones retain their proper relations without external support. A careful investigation of the kind of force which produced the injury, particularly as regards its intensity and direction of action, may aid in the diagnosis. In doubtful cases the Röntgen rays often prove useful.

Prognosis.—After having been dislocated, a joint is seldom as strong as it was formerly, although for all practical purposes the limb may be as useful as ever. Some degree of stiffness, of limited movement, or of muscular weakness, and occasional arthritic pains, and a liability to redislocation are the commonest sequelæ. Prolonged immobilisation is liable to lead to excessive stiffness by permitting of the formation of adhesions, or of fibrous thickenings of tendons or ligaments; while too early movement tends to produce a laxity of the ligaments which favours redisplacement from slight causes.

Treatment.—Reduction should be attempted at the earliest possible moment. Every hour of delay increases the difficulty. The guiding principle is to cause the displaced bone to re-enter its socket by the same route as that by which it left it—that is, through the existing rent in the capsule. This is done by carrying out certain manipulations which depend upon the anatomical arrangement of the parts, and which vary, not only with different joints, but also with different varieties of dislocation of the same joint. As the morbid anatomy of different examples of a particular dislocation varies but little, the appropriate manipulations are best studied regionally. In general terms, however, it may be said here that the main impediments to reduction are the contraction of the muscles acting upon the displaced bone; the entanglement of the bone among tendons or ligamentous bands which fix it in its abnormal position; and the rent in the capsule being small or valvular, so that it forms an obstacle to the bone re-entering the socket.

Muscular contraction is best overcome by the administration of a general anæsthetic, and in all but the simplest cases this should unhesitatingly be given to ensure rapid, accurate, and painless reduction. Failing this, however, the muscles may be wearied out by the surgeon making steady and prolonged traction on the limb, while an assistant makes counter-extension on the proximal segment of the joint. Advantage may also be taken of such muscular relaxation as occurs when the patient becomes faint, or when his attention is diverted from the injured part, to carry out the manipulations necessary to restore the bone to its normal position.

The appropriate manœuvres for disengaging the head of the bone from tendons, ligaments, or bony processes with which it may be entangled, will be suggested by a consideration of the anatomy of the particular joint involved.

It cannot be urged too strongly that any mechanical apparatus in the form of pulleys, levers, or fulcra is only to be used in exceptional cases and with the greatest care and caution. In reducing a dislocation no amount of physical force will compensate for a want of anatomical knowledge. All tugging, twisting, or wrenching movements are to be studiously avoided, as they are liable to cause damage to blood-vessels, nerves, or other soft parts, or even—and especially in old people—to fracture one of the bones concerned.

The *after treatment* consists in fixing the joint till the rent in the capsule heals—which it does very rapidly. Much benefit is gained by the systematic use of *massage* after the reduction of a dislocation. Before any restraining apparatus is applied the whole region around the joint should be gently stroked in a centripetal direction for fifteen or twenty minutes; and this is to be repeated daily, each sitting lasting for from twenty minutes to half an hour. Movement of the joint is carried out in every direction, except that which tends to bring the head of the bone against the injured part of the capsule, from the first day onward; and the patient is encouraged to use the joint as early as possible. The appropriate apparatus and the period during which it should be worn will be considered with the individual dislocations.

Operation in Simple Dislocations.—In a limited number of cases, even with the aid of an anæsthetic, reduction is found to be impossible. Resort must then be had to operation, which under aseptic conditions is a comparatively safe and satisfactory proceeding, although oftentimes difficult. It may happen that the undoing of the displacement is only possible after the removal of a portion of one or other of the bones involved.

Compound Dislocations.—Compound dislocations are usually the result of extreme violence produced by machinery or railway accidents, or by falls from great heights. In the majority of cases they are complicated by fracture of the constituent bones of the joint, as well as by laceration of muscles, tendons, and blood-vessels. In the region of the ankle, wrist, and joints of the thumb, however, compound dislocations, uncomplicated by other lesions, are sometimes met with. The great risk in compound dislocations is septic infection, which may result in serious impairment of the usefulness of the joint or even in its complete destruction, results towards which the concomitant injuries materially contribute. In many instances where septic infection has occurred, ankylosis is the best result that can be hoped for.

Treatment.—As a rule the first question that arises in the treatment of cases of compound dislocation is whether amputation is necessary or not. The considerations which determine this point are the same as in the case of compound fractures.

When an attempt is to be made to save the limb the dislocation is reduced after the parts have been thoroughly purified. In many cases excision of portions of bone is necessary to ensure asepsis or to permit of reduction. Drainage-tubes having been inserted and the rest of the wound closed, a retentive apparatus is applied, provision being made for the dressing of the wound.

Dislocation complicated by Fracture.—In certain dislocations the separation of small portions of bones or of epiphyses is of almost constant occurrence—for example, fracture of the coronoid process in dislocation of the elbow backwards, and chipping off of a portion of the edge of the acetabulum in dislocation of the hip. These neither add to the difficulties of diagnosis nor necessitate any modification of the treatment, and they need not be further referred to.

The commonest example of a fracture really complicating a dislocation is fracture of the neck of the humerus, which in a certain proportion of cases coexists with dislocation of the shoulder. Here the difficulty of diagnosis is greatly increased, and the treatment of both injuries requires to be modified. The dislocation must be reduced—by operation if necessary—before the fracture is treated, and in many cases it is advisable to secure the fragments of the broken bone by wires, pegs, or screws, to enable movement to be commenced early, and so to prevent stiffness of the joint.

Old-standing Dislocations.—When from oversight or from unsuccessful treatment a dislocated bone is left for some time unreduced, changes take place in and around the joint which render its replacement by manipulation extremely difficult or even impossible. The rent in the capsule closes upon the neck of the bone, and fibrous adhesions form between muscles, tendons, and other structures which have been torn. The articular cartilage of the head, being no longer in contact with an opposing cartilage, tends to become converted into fibrous tissue, and may form adhesions with other fibrous structures in its vicinity, or by its pressure on adjacent structures may form for itself a new socket of dense fibrous tissue which in time becomes lined with a secreting membrane. When the displaced head lies against a bone it becomes smooth and eburnated, and not infrequently spurs of bone grow out from its edges. Its continuous pressure produces a new osseous socket, from the margins of which similar osteophytic outgrowths spring, and the surrounding fibrous tissue, becoming condensed, forms a strong capsule, and a new joint results. Meanwhile the cartilage of the original socket is likewise converted into fibrous tissue, which may come to fill up the cavity, and eventually become ossified. These osseous changes often closely resemble those of arthritis deformans. The large blood-vessels and nerves in the vicin,ity may be pressed upon or stretched by the displaced bone or may be implicated in fibrous adhesions. In course of time they become lengthened or shortened in accordance with the altered attitude assumed by the limb.

In many cases the new joint is remarkably mobile and useful: but in others, pain, limited movement, atrophy of muscles and deformity render it comparatively useless and call for surgical intervention.

Treatment.—It is always a difficult problem to determine the date after which it is inadvisable to attempt reduction by manipulation, and no rules can be laid down which will cover all cases. Rather must each case be decided on its own merits, due consideration being had to the risks which attend this line of treatment. The chief of these are rupture of large blood-vessels or nerves which have formed adhesions with the displaced bone, or have become shortened in adaptation to the altered shape or length of the limb; tearing of muscles or tendons, or even of the skin; and fracture of the bone, especially in old people; and in the young, separation of epiphyses.

Before carrying out the manipulations appropriate to the particular dislocation, all adhesions must first be carefully broken down; and during the proceedings no undue force is to be employed. It is sometimes found that the displacement is very prone to recur, even after reduction has been successfully accomplished.

When reduction by manipulation is inadvisable or has been unsuccessful, the question of operation arises. In this connection it is to be borne in mind that even with an open wound the replacement of the bone is often by no means easy. If septic complications arise they are often disastrous in their results. In many cases reduction can only be effected after excision of the head of the bone, and this often leads to ankylosis, which seriously impairs the usefulness of the limb. Before deciding to operate, therefore, the surgeon has to consider such points as the degree of discomfort, deformity, and impaired function resulting from the condition, the occupation of the patient and his age.

Habitual or *recurrent dislocation* occurs in the shoulder, and will be described with the injuries of that joint.

Pathological Dislocations.—Joints may become dislocated in the course of certain diseases. These pathological dislocations fall into three groups: (1) those due to gradual stretching of the capsular and other ligaments weakened by inflammatory and suppurative processes, such as sometimes follow on typhoid, scarlet fever or diphtheria, and in pyæmia; (2) those due to destructive changes in the ligaments and bones—typically seen in tuberculous arthritis and in Charcot's disease; (3) those due to deformities such as result from altered lines of pressure in paralysed limbs, or from changes in the shape of the bones such as occur in arthritis deformans.

Pathological dislocations are usually incomplete at first, and gradually tend to become more marked as the disease progresses, until eventually the displacement is complete.

Their prevention and treatment will be considered with the diseases which give rise to them.

Congenital Dislocations.—Congenital dislocations are generally believed to be the result of abnormal or arrested development *in utero*, and are to be clearly distinguished from dislocations occurring during birth, which are essentially traumatic in origin. The pathology and clinical features of congenital dislocations will be described with deformities.

CHAPTER XXII.

INJURIES IN THE REGION OF THE SHOULDER AND UPPER ARM.

Surgical Anatomy—FRACTURES OF CLAVICLE : *Varieties*—DISLOCATIONS OF CLAVICLE : *Varieties*—DISLOCATIONS OF SHOULDER : *Varieties*—Sprains and contusions of shoulder—FRACTURES OF SCAPULA : Sites—FRACTURES OF UPPER END OF HUMERUS : *Surgical neck ; Separation of epiphysis; Fracture of head, anatomical neck, or tuberosities*—FRACTURES OF SHAFT OF HUMERUS.

THE injuries met with in the region of the shoulder include fractures and dislocations of the clavicle, fractures of the scapula, dislocations and sprains of the shoulder-joint, and fractures of the upper end of the humerus.

Surgical Anatomy.—For the examination of an injury in the region of the shoulder the patient should be seated on a low stool or chair. After inspecting the parts from the front, the surgeon stands behind the patient and systematically examines the shoulder girdle and upper end of the humerus by palpation. The uninjured side should be examined along with the other for purposes of comparison.

Immediately external to the supra-sternal notch, the sterno-clavicular articulation may be felt, the large end of the clavicle projecting beyond the margins of the small and shallow articular surface on the sternum. Any dislocation of this joint is at once recognised. The clavicle being subcutaneous throughout its whole length, any irregularity in its outline can be easily detected. A small tubercle (deltoid tubercle) which frequently exists near the acromial end is liable to be mistaken for a fracture. The outer end forms with the acromion the acromio-clavicular joint, which, however, is not very readily recognised. The fingers are now carried over the acromion, which often exhibits a prominent ridge in the situation of its epiphysial cartilage, which must not be mistaken for a fracture. The tip of the acromion is usually employed as a fixed point in measuring the length of the arm.

The outline of the spine of the scapula can be traced back to the vertebral border ; and the body of the bone may be manipulated, and its movements tested by moving the arm.

The coracoid process can be recognised in the upper and outer angle of the triangular depression bounded by the pectoralis major, the deltoid, and the clavicle.

The head and surgical neck of the humerus may now be felt from the axilla, if the axillary fascia be relaxed by bringing the arm to the side. The great tuberosity can be indistinctly felt on the outer aspect of the shoulder through the fibres of the deltoid. It lies vertically above the external condyle, and may be recognised to rotate with the shaft. The bicipital groove looks forward, and lies in a line drawn vertically through the biceps muscle.

The subclavian artery, with its vein to the inner side and the cords of the brachial plexus to the outer side, passes under the middle of the clavicle, and may be compressed against the first rib immediately above this bone.

FRACTURES OF THE CLAVICLE.

Fracture of the clavicle is one of the commonest injuries met with in practice. As about one-third of the cases occur in children, the fracture is often of the greenstick variety. These fractures are seldom compound or complicated, unless as a result of gunshot injuries; but occasionally the fragments pierce the skin, or press upon the subclavian vessels or the cords of the brachial plexus. Both clavicles may be fractured simultaneously.

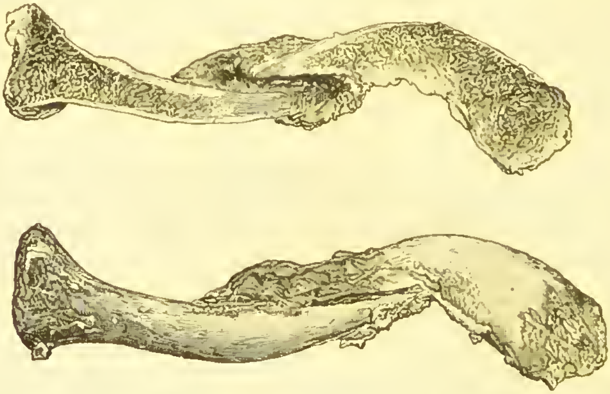

FIG. 87.—Recent Oblique Fracture of Right Clavicle in Middle Third. Upper figure shows sawn section. Lower figure shows superior aspect of bone.

The most common situation is in the *middle third* (Fig. 87). This usually results from indirect violence, such as a fall on the outstretched hand, the elbow, or the outer aspect of the shoulder, the force being transmitted through the glenoid cavity to the scapula, and thence by the coraco-clavicular ligaments to the clavicle. The violence is, therefore, of a twisting character, and the bone gives way near the junction of the outer and middle thirds, just where the two natural curves of the bone meet, and where the supporting muscular and ligamentous attachments are weakest.

The fracture so produced is usually oblique from above, downwards and inwards. The sternal fragment may be slightly drawn upwards by the sterno-cleido-mastoid, while the outer fragment falls by the weight of the arm, and the fragments usually overlap to the extent of about half an inch. The shoulder, having lost the buttressing support of the clavicle, falls in towards the chest wall, narrowing the axillary space, while the weight of the arm pulls it downward, and the muscles inserted in the region of the bicipital groove pull it forward.

Fracture of the middle third may also result from a direct stroke, such as the recoil of a gun, or from violent muscular contraction, the fracture as a rule being transverse, and the displacement less marked than in fracture by indirect violence.

Clinical Features.—The attitude of the patient is characteristic (Fig. 88). The elbow is flexed, and is supported by the opposite hand, while the head is inclined towards the affected shoulder to relax the muscles of the neck. Crepitus is elicited on bracing back the shoulders, or on attempting to raise the arm beyond the horizontal. These movements also cause pain. Tenderness is elicited on making pressure over the seat of fracture, and also on distal pressure. The sternal fragment almost invariably overrides the acromial, and can usually be palpated through the skin; on measurement the clavicle is found to be shortened. When the fracture is incomplete (greenstick) or transverse the symptoms are less marked.

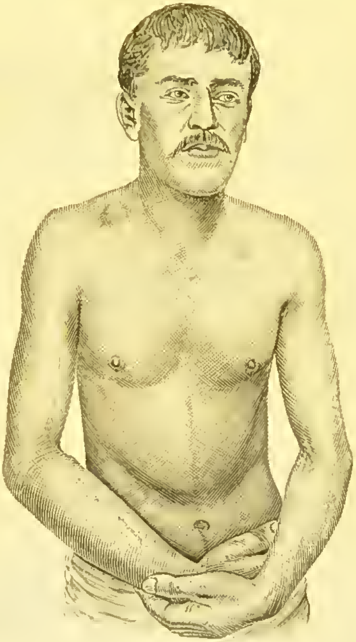

FIG. 88.—Recent Fracture of Right Clavicle in Middle Third. Note attitude and prominence of outer end of sternal fragment.

Simultaneous fracture of both clavicles usually results from a severe transverse crush of the upper part of the thorax or from a fall on the outstretched hands. The middle third of the bone is implicated, and there is marked displacement and overriding.

The patient is rendered helpless, and from the extrinsic muscles of respiration being thrown out of action, and the weight of the powerless limbs pressing on the chest, dyspnœa is a frequent accompaniment. Internal injuries often complicate these fractures.

Fracture of the *outer third* of the clavicle is much less common, and usually results from direct violence, the bone being driven down against the coracoid process, and broken as one breaks a stick over the knee. The fracture may take place at the level of attachment of the conoid and trapezoid ligaments, in which case the only symptoms are pain and tenderness at the seat of fracture, with impaired movement of the limb. Displacement and crepitus are prevented by the splinting action of the ligaments.

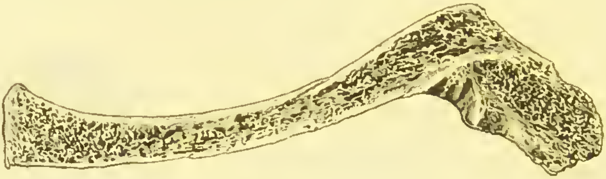

Fig. 89.—Fracture of Outer end of Clavicle. Shows forward rotation of outer fragment, and line of fracture united by osseous callus.

When the break is external to the attachment of the trapezoid ligament, the fracture is usually transverse, and is almost always due to a fall on the back of the shoulder—the angle between the spine and the acromion process striking the ground. The outer fragment rotates forward (Fig. 89), sometimes even to a right angle, causing the tip of the shoulder to pass forwards, and so to lie slightly nearer the middle line. The integrity of the coraco-clavicular ligaments prevents any marked drooping of the shoulder. It is noteworthy that the displacement is not always evident at first.

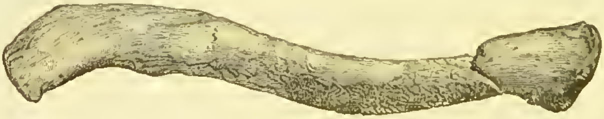

Fig. 90.—Fracture of Inner End of Clavicle.

(From a specimen in Professor Annandale's collection.)

Fractures of the *inner third* are very rare, are usually oblique (Fig. 90), and result either from an indirect force acting in the line of the clavicle, or, less frequently, from direct violence or muscular action. As a rule the deformity is insignificant, except when the costo-clavicular ligament is torn, in which case the inner end of the outer fragment is tilted up by the weight of the arm. The shoulder passes downwards, forwards, and inwards. When close to the sternal end this fracture may simulate a dislocation of the sterno-clavicular joint or a *separation of the clavicular epiphysis.* This last is a very rare accident, which may occur between the seventeenth and the twenty-fifth years, usually as a result of violent muscular action. It differs from the other injuries in this region in being easily reduced and retained in position.

The *prognosis* as to union in all these injuries is good. Firm bony union usually occurs within twenty-one days. Non-union, false joint, or fibrous union is but rarely met with. At the same time it is to be borne in mind that, in spite of all precautions, some deformity and shortening may result, without, however, interfering with the usefulness of the limb.

Treatment.—The displacement in complete fractures of the clavicle is readily reduced by supporting the elbow, bracing back the shoulders, and levering out the tip of the affected shoulder. In a few rare cases the interposition of some fibres of the subclavius muscle between the fragments has prevented perfect reduction.

In the greenstick variety the bone should be bent back into its normal position, even if the force required is sufficient to render the fracture a complete one. In spite of imperfect reduction, the clavicle usually straightens as it grows, and although some deformity may persist, the function of the limb is not interfered with.

Treatment in the Recumbent Position.—There is little doubt that the most perfect æsthetic results are obtained by treating the patient in the recumbent position. In the case of girls, therefore, in whom it is desired that the shoulders should be perfectly symmetrical, the best method of treatment is to place the patient on a firm mattress, with a narrow, firm cushion between the shoulder-blades, so that the weight of the shoulder may carry the acromial fragment outwards and backwards. A pad is inserted in the axilla, the elbow is raised, and the arm fixed by the side on a pillow with sandbags. Massage is applied daily to hasten the disappearance of the effused blood. As this position must be maintained uninterruptedly for two or three weeks, it proves too irksome for most patients. In cases of fracture of both clavicles, however, it is, short of operation, the only available method of treatment. In such cases the patient must be carefully nursed to prevent him moving the arms.

Satisfactory results may also be obtained by the method suggested by Wharton Hood. The fracture having been reduced, three strips of strong adhesive plaster, each an inch and a half wide, are applied from a point immediately above the nipple to a point two inches below the angle of the scapula. The middle strap should cover the seat of fracture, and should be first applied; the lateral ones, slightly overlapping it, should extend about half an inch on either side. The forearm is supported in a sling. This appliance has the advantage that it permits of massage and movement being carried out from the first.

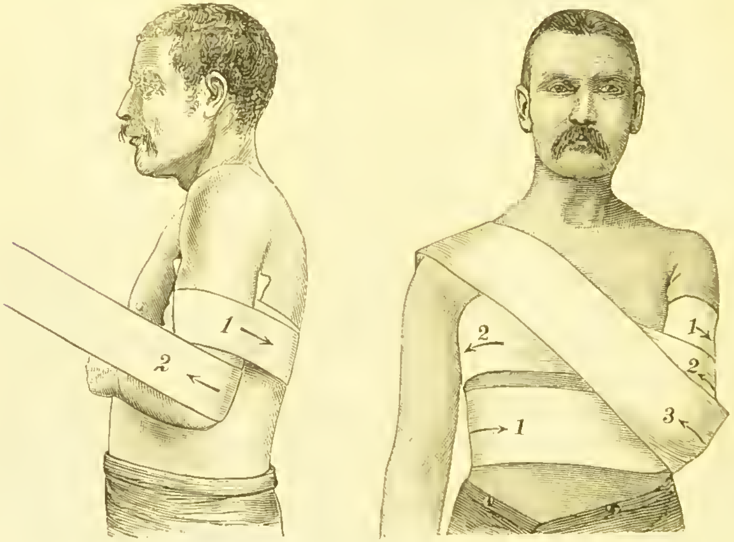

Fig. 91.—Duncan's Modification of Sayre's Method of treating Fracture of Clavicle. The *circular* body bandage has still to be applied.

Sayre's method, which is specially adapted to fractures of the middle third, although applicable to all, consists in applying broad strips of adhesive plaster in such a way as to correct the threefold deformity. While it is excellent in principle, it is often found troublesome in practice, as the plaster is irritating and uncomfortable to the patient, and if it becomes slack or fails to correct the deformity, must be completely removed and reapplied. These difficulties may be overcome by adopting *Duncan's modification*, which consists in employing a broad domette bandage in place of the adhesive plaster. A layer of wool is placed in the axilla to keep the skin surfaces apart. It must not be used as a fulcrum to lever out the shoulder, as the pressure thus produced on the axillary vessels and nerves is liable to cause congestion, and numbness or pain in the limb beyond. A wide loop is then made on the end of the bandage, and passed round the middle of the upper arm (Fig. 91), care being taken that the limb is not constricted. The arm is pulled backward by carrying the bandage across the back, under the opposite axilla, and round the thorax as far as the elbow. It is next looped round the back of the elbow, close above the condyles, and by being carried across the front of the chest to the opposite shoulder pulls the elbow forward and inwards, and so levers the shoulder backward and outward on the fulcrum formed by the loop round the upper arm. The next turn corrects the downward displacement by passing across the back, under the tip of the elbow—a slit being made in the bandage opposite the olecranon process—and along the forearm to the opposite shoulder. A circular body bandage is applied over all these turns, and safety-pins inserted at the crossings.

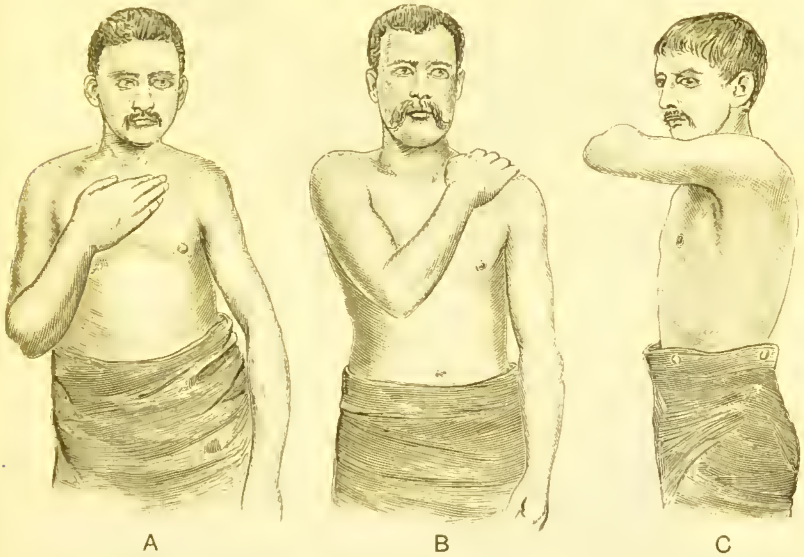

FIG. 92.—Attitudes of Limb according to Displacement in Chiene's Method.

Chiene's Method.—"In employing this method there are two points to be attended to—the position in which the arm is to be kept, and the method of applying the bandage. The more *downward* the displacement, the more *vertical* must the arm be kept (Fig. 92, A). If the displacement is *inwards*, the upper arm must be placed well *across the chest* (Fig. 92, B). If *forward* displacement is most marked, let the upper arm be placed as *horizontal* as possible (Fig. 92, C).

"Lay the tail of the bandage on the hand (Fig. 93 (1)); carry it down the back of the forearm, round the elbow, up the upper arm to the tip of the acromion (2), across the back to the opposite axilla, across the forearm (3), round the elbow again, up the upper arm, then round below the deltoid (4), and across the back to the opposite shoulder (5), repeating these turns as often as is necessary. Last of all, fix the arm to the side by circular turns."—Chiene.

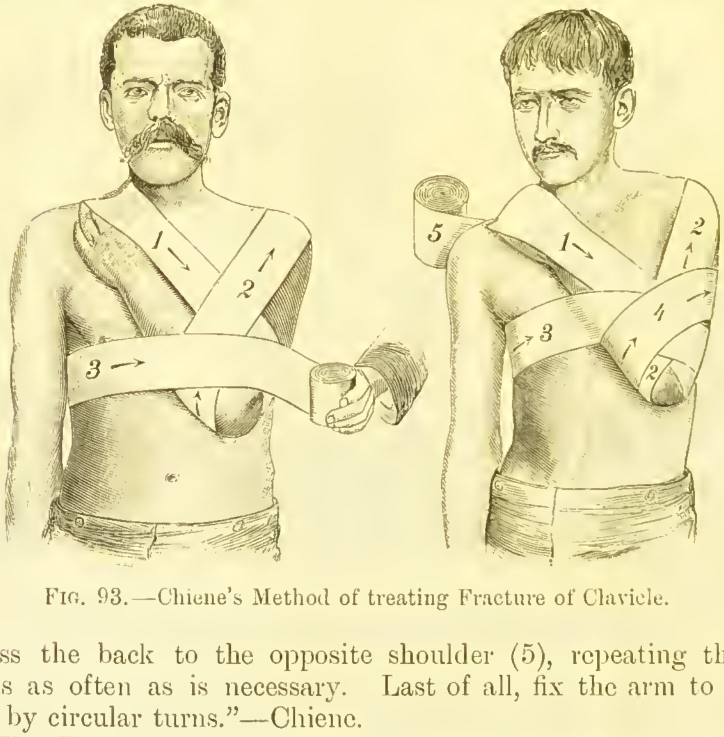

FIG. 93.—Chiene's Method of treating Fracture of Clavicle.

The Handkerchief Method.—In cases of emergency, one of the best methods applicable to all fractures of the clavicle is to brace back the shoulders by means of two padded handkerchiefs, folded *en cravate*, placed well over the tips of the shoulders and tied, or interlaced, between the scapulæ. The forearm is then supported by a third handkerchief applied as a sling, the base of which is placed under the elbow, the ends passing over the sound shoulder.

Operative treatment may be called for in compound or comminuted fractures when the fragments have injured, or are likely to injure, the subclavian vessels or the cords of the brachial plexus, or when it is otherwise impossible to reduce the fracture or to retain the fragments in apposition. It is also indicated in some cases of simultaneous fracture of both clavicles. Silver wire or silk-worm gut is the most suitable material for suture. After the wound has healed, massage and movement are employed, as in simple fractures.

DISLOCATIONS OF THE CLAVICLE.

Dislocations of the *acromial end*—sometimes, and perhaps more correctly, spoken of as dislocations of the scapula—are more frequent than those at the sternal end. This injury usually results from a blow from behind driving down the scapula, so that the clavicle projects *upwards* and overrides the acromion process (Fig. 94).

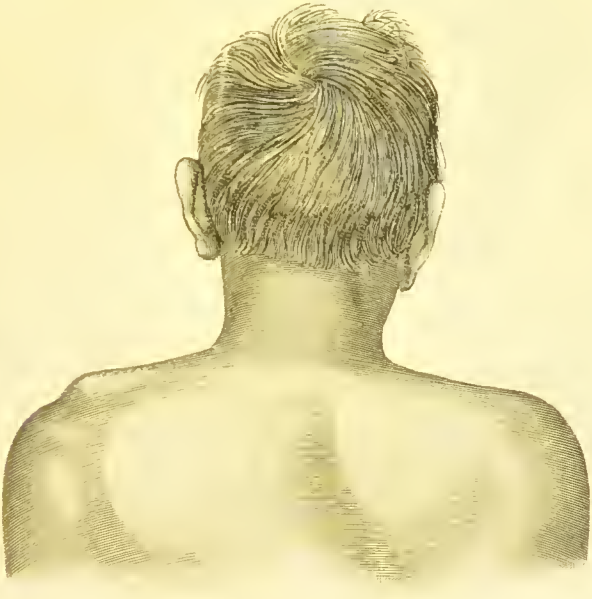

FIG. 94.—Dislocation of Acromial End of Left Clavicle upwards.

The *downward* displacement of the outer end of the clavicle is very much rarer, and may follow a fall on the elbow or a blow over the clavicle. The end of the bone lies in contact with the capsule of the joint, and under the acromion process, which stands out prominently.

At the *sternal end* the most common displacement is forward—the backward and upward dislocations being rare.

In the *forward* dislocation the head of the bone lies on the front of the sternum, somewhat below the level of the sterno-clavicular joint (Fig. 95), the interarticular cartilage sometimes remaining attached to one bone, sometimes to the other, while the rhomboid ligament usually remains intact.

When the head passes *backward* the joint cavity is felt to be empty, a marked hollow existing in this position, and the end of the clavicle lies behind the manubrium sterni and the muscles attached to it. In a comparatively small number of cases it exerts pressure upon the trachea and œsophagus, producing difficulty in breathing and swallowing. It has also been known to press upon the subclavian artery and on other important structures at the root of the neck.

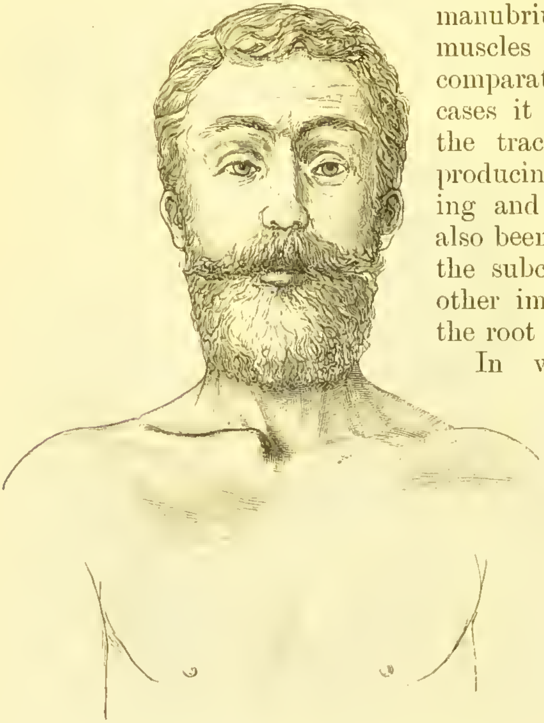

FIG. 95.—Forward Dislocation of Sternal End of Right Clavicle.

In very rare cases the rhomboid ligament being torn, the end of the clavicle passes *upward*, and rests in the episternal notch behind the sterno-mastoid muscle.

Dislocation of *both ends* of the clavicle has occasionally occurred from a severe crush. The results have been satisfactory, as one or other end has always united in normal position, and the function of the arm has thus been maintained.

Clinical Features.—In *all varieties* the clinical features are so well marked that the diagnosis is unmistakable. The head inclines towards the affected side, and the shoulder tends to pass slightly downward, forward, and inward. The displaced end of the bone can be seen and felt as a subcutaneous prominence (Figs. 94 and 95), or the empty socket can be palpated, while the muscles attached to the displaced clavicle stand out in relief. The movements of the shoulder are always restricted, particularly in the direction of abduction above the level of the shoulder.

Treatment.—Reduction is easily effected by bracing back the shoulders and employing manipulations to replace the bone in its socket; but retention is invariably difficult, and in many cases impossible, so that permanent deformity very commonly results, although the usefulness of the limb is seldom seriously impaired.

Dislocation of the *acromial end* is best treated by placing an elastic pad, such as a Turkey sponge, over the outer end of the clavicle, and fixing it in this position by a few turns of elastic bandage carried over the shoulder and under the elbow. The forearm is placed in a sling, with the elbow well supported, and the arm is bound to the side by a circular bandage (Fig. 96). When redisplacement occurs, and the usefulness of the limb is impaired, the joint surfaces may be rawed and the bones wired, with a view to obtaining ankylosis.

The *sternal end* may be kept in position by firmly bracing back the shoulders by a figure-of-eight bandage, or by padded handkerchiefs, and making pressure over the displaced end of the bone with a large sponge pad or a few strips of adhesive plaster. The forearm is supported by a sling, and the arm fixed to the side. Imperfect reduction interferes so little with the functions of the limb that operative measures are seldom required except for æsthetic reasons.

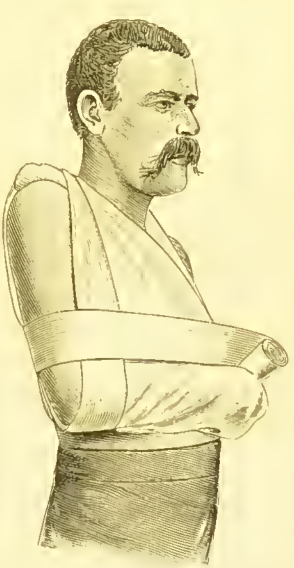

FIG. 96.—Treatment of Upward Dislocation of Acromial End of Clavicle.

It may be found useful to supplement these appliances by a shoulder-cap, especially in muscular or refractory patients. The patient should be confined to bed for a few days. Massage should be employed from the first, and the patient should be allowed to begin to move the arm by the end of a week.

DISLOCATIONS OF THE SHOULDER.

The shoulder is more frequently dislocated than all the other joints in the body taken together. This is explained by its exposed position, the wide range of movement of which it is capable, the length of the lever afforded by the humerus, and the anatomical construction of the joint—the large, round humeral head imperfectly fitting the small and shallow glenoid cavity, and the ligaments being comparatively lax and thin. The capsule of the joint is materially strengthened in its upper and back parts by the tendons of the supra- and infra-spinatus and teres minor muscles; while it is weakest below and in front between the subscapularis and teres major tendons. It is here that it most frequently gives way and allows of displacement of the head of the bone.

The violence is usually transmitted from the hand or elbow, less frequently from the outer aspect of the shoulder, the limb being at the moment abducted and the muscles relaxed and taken unawares. The head of the humerus, thus brought to bear on the weakest part of the capsule, ruptures it and passes out through the rent. Dislocation is very readily produced in an unconscious patient, and sometimes occurs in conducting artificial respiration or in handling a patient suffering from opium poisoning.

Several *varieties* of dislocation are recognised according to the position in which the head of the humerus finally rests. The simplest and least complicated of these is the *sub-glenoid* variety, in which the head rests on the long head of the triceps where it arises from the axillary border of the scapula just below the glenoid cavity. In almost all cases of dislocation of the shoulder the head of the bone is at least momentarily in this position, but the sharp edge of the scapula and the rounded head are ill adapted to one another, and the position is not long maintained. The subsequent course taken by the humerus depends upon the nature and direction of the force, the position of the limb at the moment of injury, and the relative strength and capacity for effective action of the different groups of muscles acting upon the bone.

In the great majority of cases it passes forward and inward, and comes to lie against the anterior surface of the neck of the scapula, under cover of the tendons of origin of the biceps and coraco-brachialis muscles, constituting the *sub-coracoid dislocation.* Much less frequently it passes still farther in and lies under the pectoralis minor and against the edge of the clavicle—the *sub-clavicular* variety. In rare cases the head passes backward and lies against the spine on the dorsum of the scapula, beneath the infraspinatus muscle—the *subspinous* variety. Other varieties are so rare that they do not call for special mention.

Clinical Features common to all Varieties.—Dislocations of the shoulder are commonest in adult males. In advanced life the proportion of female sufferers increases. They are usually attended with great pain, and there is often numbness of the arm due to pressure of the head of the bone upon the large nerve trunks. There is sometimes considerable shock. The patient inclines his head towards the injured side, and while standing the forearm is supported by the hand of the opposite side. The acromion process stands out prominently, the roundness of the shoulder giving place to a flattening or depression immediately below it, so that a straight edge applied to the outer aspect of the limb touches both the acromion and the external condyle. The vertical circumference of the axilla is markedly increased. The head of the bone is to be felt in its new position, and the direction of the humerus is correspondingly altered, the elbow being carried from the side—forward or backward according to the position of the head. The empty glenoid may sometimes be palpated from the axilla. In most cases, although not in all, the patient is unable at one and the same time to bring his elbow to the side and to place the hand upon the opposite shoulder (Dugas' symptom). Accurate measurements of the length of the limb from acromion to external condyle are not easily made, and are rarely of any diagnostic value.

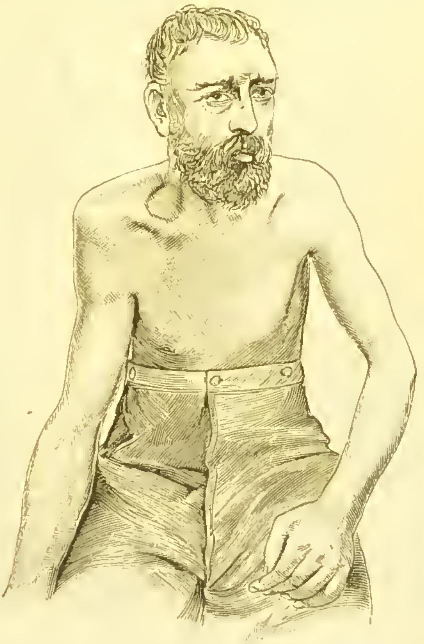

FIG. 97.—Sub-coracoid Dislocation of Shoulder. Note flattening of shoulder, increase in depth of axillary fold, and congestion of veins of arm.

The *sub-coracoid* dislocation (Fig. 97) is that most frequently met with. It usually results from hyper-abduction of the arm while the scapula is fixed, as in a fall on the inner side of the elbow when the arm is slightly abducted from the side. The surgical neck of the humerus is then brought to bear upon the under aspect of the acromion, which forms a fulcrum, and the head of the humerus is pressed against the inner and lower part of the capsule. In some cases muscular action produces this dislocation, the mechanism being the same as when it is due to indirect violence. It may also result from force directly applied in the region of the shoulder.

The head leaves the capsule through the rent made in its lower part, and, either from a continuation of the force, or from the contraction of the muscles inserted into the bicipital groove, particularly the great pectoral, passes inwards under cover of the biceps and coraco-brachialis till it comes to rest against the anterior surface of the neck of the scapula, just below the coracoid process. The anatomical neck of the humerus presses against the anterior edge of the glenoid, and there is frequently an indentation fracture of the head of the humerus where the two bones come into contact (F. M. Caird). The subscapularis is bruised or torn, the muscles inserted into the great tuberosity are greatly stretched, or the tuberosity itself may be avulsed, allowing the long tendon of the biceps to slip outwards, where it may form an impediment to reduction. The circumflex nerve is often bruised or torn, and the head of the humerus is liable to press injuriously on the axillary nerves and vessels.

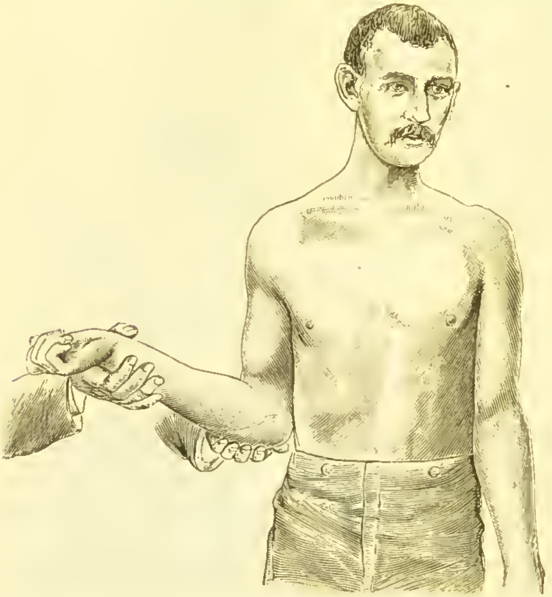

Fig. 98.—Kocher's Method of reducing Sub-coracoid Dislocation—First Movement: External Rotation of Arm.

The *clinical features* common to all dislocations are prominent, although Dugas' symptom is not constant.

Treatment.—It must ever be kept in mind that the guiding principle in the reduction of these dislocations is to make the head of the bone retrace the course it took in leaving the socket. The main obstacles to reduction being muscular contraction and the entanglement of the head with tendons, ligaments, or bony points; appropriate means must be taken to counteract each of these factors.

A general anæsthetic is an invaluable aid to speedy and accurate reduction, and should always be given unless there is some reason for withholding it. It is clearly indicated in strong, muscular subjects, and particularly when the dislocation is of some standing, and in nervous patients who do not bear pain well. In quite recent cases, however, the surgeon may sometimes succeed in replacing the bone by taking advantage of a temporary faintness, or by engaging the patient's attention with other matters while he carries out the appropriate manipulations.

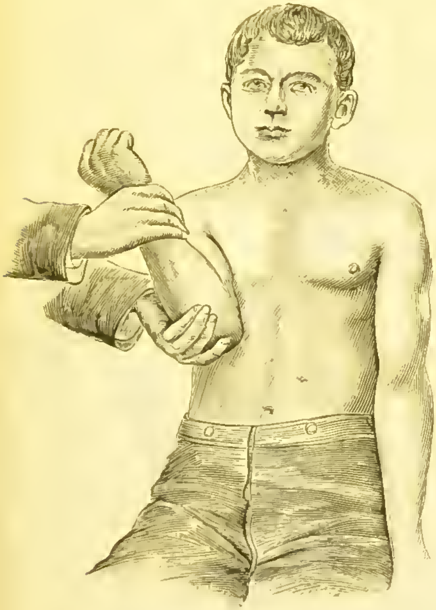

FIG. 99.—Kocher's Method—Second Movement: Elbow carried forward, upward, and towards the Middle Line.

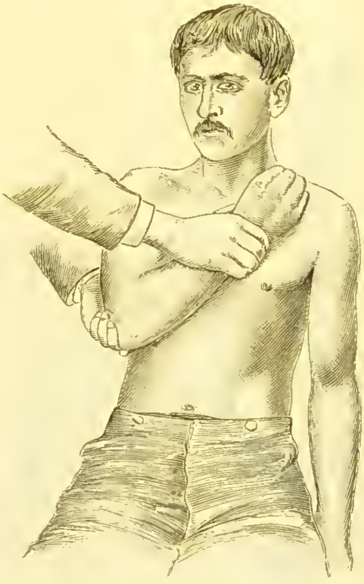

FIG. 100.—Kocher's Method—Third Movement: Inward Rotation of Arm.

When an anæsthetic is employed the patient should be laid on a mattress on the floor, or on a narrow, firm table; otherwise he should be seated on a chair.

Kocher's method is suitable for the great majority of cases of sub-coracoid dislocation. (1) The elbow is firmly pressed against the side, and the forearm flexed to a right angle. The surgeon grasps the wrist and elbow and firmly *rotates the arm outward* (Fig. 98) till distinct resistance is felt and the deltoid becomes more prominent. In this way the rent in the lower part of the capsule is made to gape, and the head of the humerus rolls outwards till it lies opposite the opening, rotation taking place about the fixed point formed by the contact of the anatomical neck of the humerus with the anterior lip of the glenoid cavity (Waterston). (2) The *elbow is next carried forward, upward, and toward the middle line* (Fig. 99), the humerus acting as the long arm of a lever on the fulcrum furnished by the muscles inserted in the region of the surgical neck; the head, which forms the short arm of the lever, is carried backward, downward, and outward, and is thus directed towards the socket. (3) The arm is now *rotated inward* by carrying the hand across the chest towards the opposite shoulder (Fig. 100). The anatomical neck of the humerus is thus disengaged from the edge of the glenoid, and the head is pulled into the socket by the tension of the surrounding muscles.

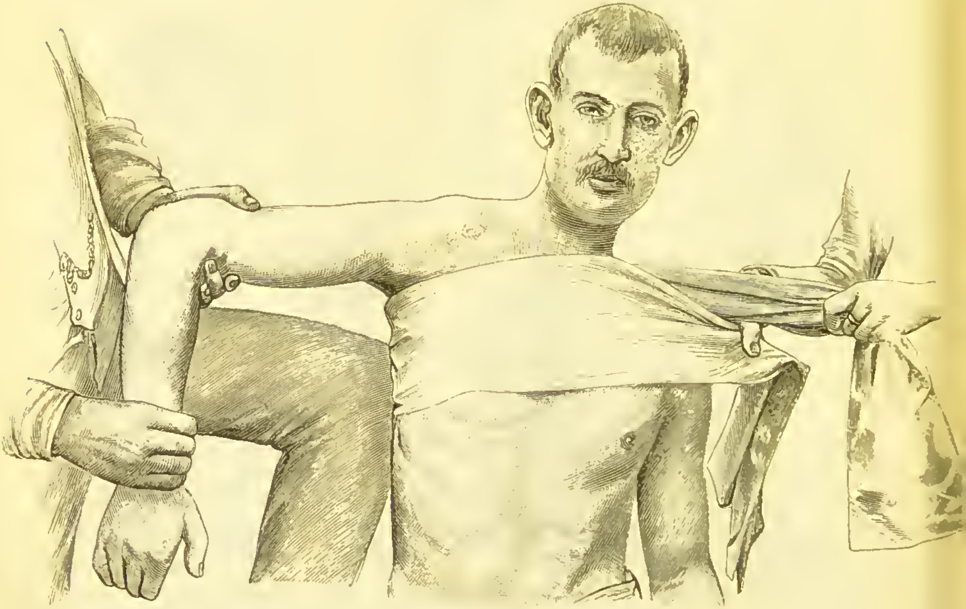

FIG. 101.—Miller's Method of reducing Sub-coracoid Dislocation—Second Movement.

A method of reduction has been formulated by Mr. A. G. Miller which is often efficacious. The limb is grasped above the wrist and elbow, the forearm flexed to a right angle, and the upper arm abducted to the horizontal. While an assistant makes counter-extension and fixes the scapula, the surgeon gradually draws the arm out from the body till the head of the humerus is felt to pass outwards. The humerus is then rotated inwards by dropping the hand (Fig. 101), and the bone gradually glides into the socket.

In a certain number of cases reduction can be effected by *hyper-abduction with extension* at the shoulder. The patient is laid upon a firm mattress, and the scapula fixed by making pressure on the acromion, while the arm is slowly and steadily extended, and raised from the side till it is well above the head. In some cases the head of the humerus spontaneously slips into its socket; in others it may be manipulated into position by pressure from the axilla. This method is best adapted to recent cases, as in those of long standing the axillary vessels are liable to be stretched or torn.

The method of reduction by traction on the arm with the heel in the axilla has deservedly fallen into disrepute as being one which largely depends for its success on sheer force.

After Treatment.—After reduction the part is gently massaged for ten or fifteen minutes, a layer of wool is placed in the axilla, the forearm is supported by a sling, and the arm fixed to the side by a circular bandage. Massage is carried out daily. Movement of the shoulder, in every direction except that of abduction, may be commenced on the third or fourth day. The restraining apparatus may be dispensed with at the end of a fortnight or three weeks, and by the end of a month the patient should be advised to use the arm freely.

The *sub-clavicular* dislocation is to be looked upon as an exaggerated form of the sub-coracoid rather than as a separate variety. It is produced by the same mechanism, but the violence is greater, and the resulting lesions are correspondingly severe. The head passes farther in under cover of the pectoralis minor, resting under the clavicle against the serratus magnus and chest wall. The ordinary clinical features are usually so marked that they leave no doubt as to the diagnosis. The outline of the head of the humerus is visible through the skin in its abnormal position, and the shortening of the limb is more marked than in the sub-coracoid variety. The treatment is the same for both varieties.

Sub-glenoid dislocation is less frequently met with than the sub-coracoid variety, and almost always results from forcible abduction of the arm. The head of the humerus passes out through a small rent in the lower and inner portion of the capsule, and rests against the anterior edge of the triangular surface immediately below the glenoid cavity, supported behind by the long head of the triceps, and in front by the subscapularis muscle. It is readily felt in the axilla. All the tendons in relation to the upper end of the humerus are stretched or torn, and the great tuberosity is not infrequently avulsed. The circumflex nerve is particularly liable to be damaged.

The projection of the acromion, the flattening of the deltoid, the lengthening of the axillary fold, and the abduction of the elbow are very marked; the arm is slightly lengthened, rotated out, and carried forward. It is readily reduced by the same manipulations as in the sub-coracoid variety.

Backward dislocation is usually termed *sub-spinous*, although in a considerable proportion of cases the head of the humerus does not pass beyond the root of the acromion process (*sub-acromial*). This dislocation is usually produced by a fall on the elbow, the arm being at the moment adducted and rotated in, so that the head of the humerus is pressed backwards and outwards against the capsule, which ruptures posteriorly. The muscles attached to the upper end of the humerus are all liable to be torn, and the tuberosities are frequently avulsed.

In the milder cases the *clinical features* are not always well marked, and on account of the swelling from effusion this dislocation is apt to be overlooked. In addition to the ordinary symptoms, the shoulder is broadened, there is a marked hollow in front in which the coracoid projects, and the arm is held close to the side with the elbow directed forward. The head of the bone may be seen and felt in its abnormal position below the spine of the scapula.

Reduction can usually be effected by making traction on the arm with internal rotation, and pressing the head forward into position, while counter-pressure is made upon the acromion.

Prognosis.—The ultimate prognosis in dislocations of the shoulder should always be guarded. The circumflex nerve may be stretched or torn, and this may lead to atrophy of the deltoid, or other branches of the brachial plexus may be injured, and the muscles they supply permanently weakened. In a certain number of cases traumatic neuritis has resulted in serious functional disability of the whole limb. The movements of the shoulder-joint may be restricted by cicatricial contraction of the torn portion of the capsule and of the damaged muscles. Habitual dislocation may follow if the capsule becomes too lax or if the rent fails to close.

Dislocation of the Shoulder complicated with Fracture of the Humerus.—This double injury is fortunately very rare. The dislocation, which is almost invariably of the sub-coracoid variety, is produced by the usual mechanism of forced abduction, and the fracture takes place by the violence continuing to act after the head has left the glenoid fossa. The neck of the humerus has frequently been fractured during attempts to reduce an old-standing dislocation. As a rule the fracture implicates the surgical neck, the lower fragment lying outside the upper and being displaced upwards. The head may be felt in its abnormal position but does not move with the shaft when the humerus is rotated; crepitus, abnormal mobility, and shortening of the limb can usually be recognised. A general anæsthetic is almost always necessary to permit of an exact diagnosis being made, as well as to aid in reduction.

The first indication in *treatment* is to reduce the dislocation. In certain cases, where the head lies close to the glenoid cavity and the capsule is widely lacerated, this may be done by manipulating the upper fragment from the axilla. On no account should the lower fragment be employed as a lever in attempting reduction. When reduction by external manipulation fails, the upper fragment should be exposed by an incision over its outer aspect, and gripped by forceps or held by M'Burney's hook, which is specially constructed for the purpose of serving as a lever with which to return the head to its socket.

Reduction having been accomplished, the fracture is then adjusted in the usual way, advantage of the open wound being taken, if necessary, to wire, peg, or otherwise fix the fragments together. Massage and movement should be commenced early to prevent stiffness of the joint.

When it is found impossible to reduce the dislocation, the upper fragment should be removed, and a false joint allowed to form between the lower fragment and the glenoid.

The method of allowing the fracture to unite without reducing the dislocation, and then attempting reduction, usually results in rebreaking the bone, or else in failure to replace the head in the socket. It has nothing to recommend it, and should never be practised.

Old-standing Dislocations of the Shoulder.—As has already been said in discussing the general question of old-standing dislocations, it is impossible to lay down definite rules as to the date after which it is inadvisable to attempt reduction by manipulation. Experience of a hundred cases in Bruns' clinic led Finckh to conclude that, provided there be no complications, reduction can generally be effected within four weeks of the accident; that within nine weeks the prospect of succeeding is fairly good; but that beyond that time reduction is exceptional.

The patient is anæsthetised, and all adhesions broken down by free, yet gentle movement of the limb. The appropriate manipulations for the particular dislocation are then carried out, great care being taken that no undue force is employed.

Should these measures fail, the question of operation must then be considered in the light of the patient's age, general condition and occupation, and of the usefulness of the affected limb. If operation be deemed advisable, a few days should be allowed to elapse to permit of the parts recovering from the effects of the manipulations, as septic infection is favoured by the presence of torn or ecchymosed tissues. The joint is freely exposed, the capsule divided, the head of the bone freed and returned to the glenoid cavity. This is often so exceedingly difficult that it may be necessary to resect the head of the bone and aim at the formation of a new joint, an operation which usually yields excellent results.

Habitual or Recurrent Dislocation.—Cases are occasionally met with in which the shoulder-joint shows a marked tendency to be dislocated from causes altogether insufficient to produce displacement under ordinary circumstances. This condition is usually met with in young women, and in some cases at least appears to be due to too early and too free movement of the joint after an ordinary dislocation, so that the capsule is stretched and remains lax. The condition also occurs with considerable frequency in epileptics; and in them it is generally found that the head of the bone is deficient, either as a result of fracture or disease; that the muscles which naturally support the joint are atrophied or torn; and that the capsule is unduly lax. The facility and frequency with which dislocation occurs render the limb comparatively useless, and keep the patient in a constant state of apprehension.

The *treatment* consists in preventing the patient making the particular movements which tend to produce the dislocation. These are chiefly movements of hyper-abduction and overhead movements, such as are made, for example, in swimming or in arranging the hair. We have found an apparatus consisting of a belt applied round the thorax, and fixed to another round the upper arm by a band which passes above the axillary fold of the dress, useful in restraining these movements. Massage, electricity, and movements against resistance are employed, if necessary, to strengthen the weak muscles. If, after a prolonged trial, these measures fail, it may be advisable to tighten up the lax capsule by an open operation.

Sprains of the shoulder-joint are comparatively rare because of the wide range of movement of which it is capable. The whole region becomes swollen and tender to pressure, the point of maximum tenderness being over the front of the joint, just below the acromion process. Pain is also elicited when the head of the humerus is brought to bear on the glenoid cavity, or when the ligaments or tendons are put upon the stretch by manipulating the arm.

Contusions of the region of the shoulder, on the other hand, are exceedingly common. Diffuse extravasation of blood may take place in the subcutaneous tissue or in the substance of the deltoid, or a hæmatoma may form either in the muscle or in the sub-deltoid bursa. The patient is often totally unable to abduct the arm at the shoulder-joint. These injuries are liable to be followed by prolonged pain and stiffness in the upper arm. The deltoid frequently undergoes considerable atrophy, and there is severe neuralgic pain in the circumflex nerve, especially marked in the region of the insertion of the deltoid.

In both conditions improvement usually follows the employment of massage and galvanism. Blistering is of value in some cases.

Fractures of the Scapula.

Fractures of the scapula may implicate the body, the surgical neck, the acromion, or the coracoid process. They are very rarely compound.

Fracture of the Body.—Considering its exposed position, the body of the scapula is comparatively seldom fractured, doubtless because of its mobility, and the support it receives from the elastic ribs and soft muscular cushion on which it lies. It is most frequently broken by severe blows, crushes, and gunshot injuries. The scapula presents two natural arches—one longitudinal, the other transverse—and its outer and inner edges are supported by the chest wall and shoulder respectively. When the bone is crushed or struck, therefore, the force acts indirectly, and produces fracture by undoing its curves (E. H. Bennett). A main fissure usually runs transversely across the infraspinous fossa, with secondary cracks radiating from it. In other cases the line of the primary fracture is longitudinal, passing through the spine and involving both fossæ.

The *clinical features* are often obscured by swelling of the overlying soft parts. Crepitus may sometimes be elicited by placing one hand firmly over the bone, and with the other moving the arm and shoulder. When the spine is implicated the fragments may be grasped through the skin and made to move upon one another. The displacement, which usually consists in overlapping of the fragments,—although sometimes they are drawn apart,—is partly due to the action of the serratus magnus and teres major muscles, and partly depends on the direction of the force. Movement is restricted and painful. Union is usually rapid and good, and although displacement often persists, the function of the limb is unimpaired.

Treatment.—As these fractures are usually complicated by other injuries, especially of the thorax, and are accompanied by severe shock, it is nearly always necessary to confine the patient to bed. It is usually sufficient to fix the arm and shoulder to the chest wall by a firm binder, or strips of adhesive plaster, in the position which admits of the most complete apposition of fragments. This retentive apparatus is employed for about three weeks, after which the patient is allowed to use his arm. After the first week the bandages are removed daily to admit of the parts being massaged.

Fracture of the *surgical neck of the scapula*, although a rare accident, is of considerable clinical importance, as it is liable to be mistaken for a dislocation of the shoulder. The line of fracture runs through the suprascapular notch downwards and outwards to the lower margin of the glenoid, so that the glenoid and the coracoid process are separated from the rest of the bone.

The coraco-acromial and coraco-clavicular ligaments are usually widely torn, and the detached fragment, along with the head of the humerus, sinks into the axilla, causing a flattening of the shoulder, and leaving a depression below the projecting acromion. The arm is lengthened by about an inch. By supporting the arm the deformity is at once reduced, but recurs as soon as the support is withdrawn. Crepitus is usually detected on carrying out this manipulation; and the coracoid process is found to move with the arm and not with the scapula. By these tests this injury is distinguished from a dislocation.

A partial fracture carrying away the lower part of the glenoid cavity sometimes simulates a sub-glenoid dislocation. This is, however, a very rare injury.

The *treatment* is the same as for fracture of the middle third of the clavicle; the elbow being well supported by a sling. Passive movement and massage are employed from the first, to avoid stiffness of the shoulder; and the retentive apparatus should be kept on for about four weeks.

Fracture of the Acromion Process.—In considering this fracture, reference must be made to a condition frequently met with, in which the epiphysial portion of the acromion is found to be separate from the body of the process. This is by some

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(Symington, Hamilton) looked upon as a want of union of the epiphysis, but the weight of evidence seems to prove that it is rather of the nature of an ununited fracture at this level, even when, as sometimes happens, it is bilateral (Struthers, Lane). If this be so, then fracture of the acromion is the commonest fracture of the scapula, although it is often overlooked clinically on account of the swelling resulting from bruising of soft parts, and the absence of marked displacement. By careful palpation, crepitus and an irregularity at the seat of fracture may sometimes be detected. The shoulder is slightly flattened, and abduction of the arm is difficult. In rare cases the fracture passes into the acromio-clavicular joint, and is associated with dislocation of the clavicle.

Between the fourteenth and twenty-second years the *epiphysis* may be separated, but it is seldom possible to make a positive diagnosis of this injury. As is the case in all fractures of the acromion, the resulting union is usually fibrous.

The *treatment* is the same as for fracture of the clavicle.

Fracture of the coracoid is exceedingly rare. It may result from direct violence, such as the recoil of a gun, but is more often an accompaniment of dislocation of the shoulder or of the outer end of the clavicle upward. As the coraco-clavicular ligaments usually remain intact, there is no displacement; but when these are torn the coracoid is dragged downwards and outwards by the combined action of the pectoralis minor, biceps, and coraco-brachialis muscles. Crepitus may be elicited on moving the fragment.

The *treatment* consists in placing the arm across the front of the chest, to relax the muscles causing the displacement, and retaining it in that position by a sling and roller bandage.

FRACTURES OF THE UPPER END OF THE HUMERUS.

For clinical purposes it is most convenient to study fractures of the upper end of the humerus in the following order: (1) fracture of the surgical neck; (2) separation of the epiphysis; (3) fracture of head, anatomical neck, or tuberosities.

Fracture of the Surgical Neck.—The surgical neck of the humerus extends from the level of the epiphysial junction to the insertion of the pectoralis major and teres major muscles, and it is within these limits that most fractures of the upper end of the bone occur. They are most common in adults, and usually follow direct violence applied to the shoulder, but may result from falls on the hand or elbow, or from violent muscular action, as, for example, in throwing a stone. The fracture is usually transverse, and there is often little or no displacement, the fragments being retained in position by the long tendon of the biceps and the long head of the triceps. When the fracture is oblique, the fragments are often comminuted, and sometimes impacted. The displacement of the upper fragment seems to depend upon the attitude of the limb at the moment of fracture. When the upper arm is approximated to the side, the upper fragment retains its vertical position, but is slightly rotated outwards by the muscles inserted into the greater tuberosity, while the lower fragment is drawn upwards and inwards towards the coracoid process by the longitudinal muscles of the upper arm, and may be felt in the axilla. The elbow points outwards and backwards, and the upper arm is shortened. The shoulder retains its rotundity, but there is a slight hollow some distance below the acromion. On moving the shaft it is found that the head and tuberosities do not move with it, and unnatural mobility and crepitus at the seat of fracture may be detected. When the upper arm is abducted at the moment of fracture, the upper fragment is retained in that position by the external rotator and abductor muscles inserted into it, while the lower fragment passes upwards and inwards as before.

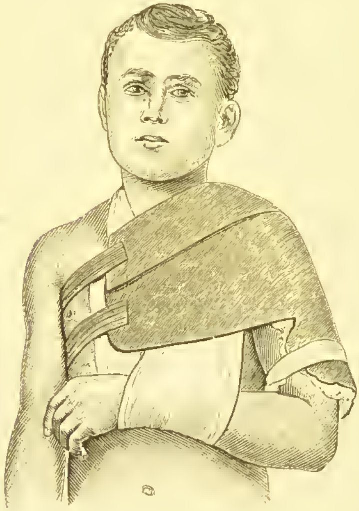

FIG. 102.—Sling and Poroplastic Shoulder-Cap applied for Fracture of Surgical Neck of Humerus.

Although there is sometimes overlapping and broadening after union, the usefulness of the limb is seldom impaired.

Treatment.—To ensure accurate reduction, as well as to confirm the diagnosis, a general anæsthetic is usually necessary. If the fracture is *transverse* there is little tendency to redisplacement. As the line of fracture is too high up in the axilla, and the bones too deeply placed among muscles to permit of the fragments being controlled by local splints applied so as to surround the fracture, we must depend upon immobilisation of the joints above and below to ensure fixation. A soft, elastic pad of cotton wool is placed in the hollow of the axilla, and fixed in position by a triangular handkerchief or figure-of-eight bandage. The shoulder-joint is controlled by a poroplastic shoulder-cap (Fig. 102), the elbow by a rectangular splint, and the forearm is supported by a sling.

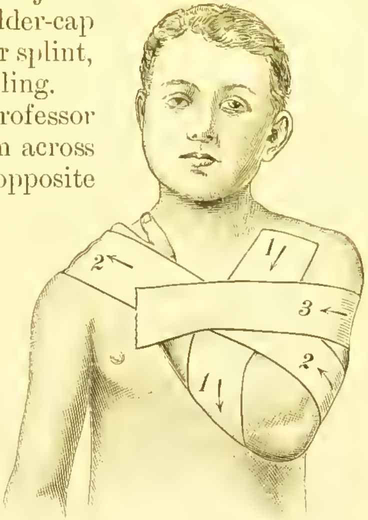

Fig. 103.—Chiene's Bandage for Fracture of Surgical Neck of Humerus. The turns fixing the arm to the chest are not figured.

Another method, described by Professor Chiene, is as follows: "Lay the arm across the chest, and the hand over the opposite shoulder. The tail of the bandage is then placed on the shoulder of the injured arm and carried down the upper arm, round beneath the elbow and up along the back of the forearm to the opposite shoulder, then across the back to below the deltoid of the injured arm, round the upper arm to the elbow, repeating as often as necessary. Last of all, fix the arm to the chest by circular turns" (Fig. 103). When the fracture is *oblique* there is considerable tendency for the lower fragment to be redisplaced upward. In such cases care must be taken to avoid supporting the elbow by splint or sling, and it may even be necessary to apply extension to counteract this tendency (Fig. 104).

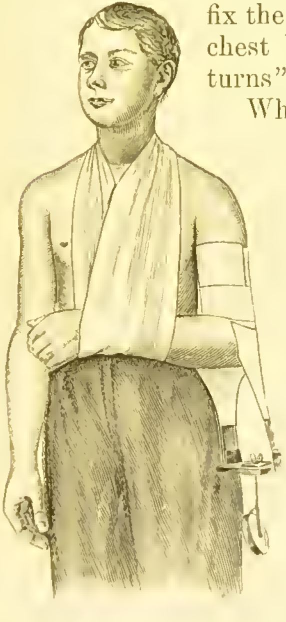

Fig. 104.—Weight Extension applied for Oblique Fracture of Surgical Neck of Humerus.

In those cases where the upper fragment remains abducted, or when the fracture is oblique or comminuted and redisplacement occurs, the patient may be treated in bed, and extension with weight and pulley carried over the side of the bed; or Middeldorpf's triangular splint may be used. This consists of a double-inclined plane, the base of which is fixed to the patient's side, while the injured arm rests on the other two sides of the triangle.

Should these measures fail, the fracture may be exposed by an incision carried along the anterior border of the deltoid, and the ends pegged, wired, or otherwise mechanically fixed, after which the limb is put up in one of the ways already described.

After Treatment.—The apparatus should be worn for three or four weeks, massage being commenced on the second or third day. Union is usually complete in about four weeks.

Separation of Epiphysis.—The upper epiphysis of the humerus includes the head, both tuberosities, and the upper fourth of the bicipital groove. On its under aspect is a cup-like depression into which the central portion of the diaphysis fits. This epiphysis unites about the twenty-first year.

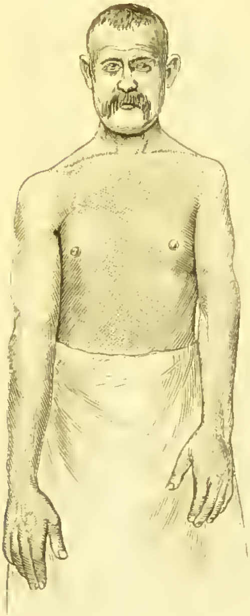

FIG. 105.—Shortening of Upper Arm from Injury to Upper Epiphysis in Childhood.

Traumatic separation is chiefly met with between the fifth and fifteenth years, and is most common in males. It usually results from forcible traction of the arm upwards and outwards, or from direct violence, but may be caused by a fall on the outer side of the elbow.

If the periosteum is not torn, the epiphysis, especially in young children, may be separated without being displaced, or the displacement may be incomplete. When complete separation occurs, the clinical features closely resemble those of fracture of the surgical neck, and the diagnosis is made by a consideration of the age of the patient, and the muffled character of the crepitus, when it can be elicited. The upper end of the diaphysis forms a projecting edge which may be felt nearer the coracoid process than in fracture of the surgical neck. Dislocation is so rare at the age when separation of the epiphysis is possible that these injuries are not likely to be confused with one another.

Reduction is often difficult, on account of the periosteum and other soft tissues getting between the fragments, and on account of the small size of the upper fragment preventing its being manipulated. Strong, firm union almost invariably results, but the growth of the limb may be seriously interfered with (Fig. 105), and its shape is sometimes much altered, especially when the injury occurs at a very early age and its nature is overlooked. Pressure on the axillary vessels and nerves has in some instances led to gangrene of the arm.

Treatment.—This injury is treated on the same general lines as fracture of the surgical neck, but the details are usually more difficult to carry out, on account of the shortness of the upper fragment, the extensive laceration of soft parts which usually occurs, and the restlessness and intractability of the patient. The difficulty is greatest when the separation is complete or the lesion compound. General anæsthesia is almost always necessary to secure satisfactory reduction, and retention is often only possible if the patient is confined to bed and an extension apparatus applied. Operative treatment is more frequently called for than in fracture of the surgical neck. In some cases it is possible to replace the fragments and fix them in position by pegs or wire ; more frequently resection of the upper end of the diaphysis is necessary before they can be approximated ; and in some cases it has even been found necessary to remove the epiphysis.

Fractures of the Head, Anatomical Neck, and Tuberosities of Humerus.—These fractures are met with as accompaniments of dislocations of the shoulder, and as results of gunshot wounds, blows, or falls.

In sub-coracoid dislocations the *head* of the humerus is often indented by coming in contact with the anterior edge of the glenoid cavity.

The *anatomical neck* may be fractured by a direct blow on the shoulder in an old person. In a few rare cases the fracture is entirely intra-capsular, the head of the bone remaining loose in the cavity of the joint. As a rule, however, the fracture passes through the anatomical neck only on the inner side, diverging into the tuberosities externally. In some cases there is impaction, and in others comminution of the fragments. The use of the X-rays has shown that in many cases of severe contusion of the shoulder, followed by prolonged stiffness, the anatomical neck has been fractured.

The *tuberosities* may be implicated in other fractures in this region, and either of them may be separated by muscular or by direct violence.

Clinically all these injuries are difficult to diagnose with accuracy, and in many cases it is impossible to go further than to say that a fracture exists above the level of the surgical neck. Fracture of the anatomical neck is attended with little deformity beyond slight flattening of the shoulder and shortening of the upper arm. When the great tuberosity is torn off, considerable antero-posterior broadening of the shoulder may be recognised by grasping the region of the tuberosities between the finger and thumb. Crepitus may be elicited on rotating the humerus. At the same time it will be recognised that the tuberosity does not move with the shaft. There is no shortening of the limb as the shaft remains intact. Firm union, with considerable formation of callus and some broadening of the shoulder, usually results, but the usefulness of the joint is not necessarily impaired. There may, however, be prolonged stiffness, and impaired movement from adhesions; or pain and crackling in the joint may result from arthritic changes of the nature of arthritis deformans.

Treatment.—These fractures may be treated by a shoulder-cap, sling, and rectangular splint. Massage and movement should be commenced within a few days of the injury, to avoid stiffness of the shoulder. Operative treatment is seldom called for.

Fracture of the Shaft of the Humerus.

Fractures occurring in the shaft of the humerus, between the surgical neck and the base of the condyles, may, for convenience of description, be divided into those above, and those below, the level of the deltoid insertion—the majority being in the latter situation.

Direct violence is the most common cause of these fractures, but they may occur from a fall on the elbow or hand; and a considerable number of cases are on record where the bone has been broken by muscular action,—as in throwing a cricket-ball. Twisting forms of violence may produce spiral fractures (Fig. 81).

The fracture is usually transverse in children and in cases where it is due to muscular action. In adults, and when due to external violence, on the other hand, it is usually oblique, the fragments overriding one another and causing shortening of the limb. The displacement depends largely on the direction of the force and the line of the fracture, but to a certain extent also on the action of muscles attached to the fragments. Thus, in fractures above the insertion of the deltoid the upper fragment is usually dragged inward by the muscles inserted into the bicipital groove, while the lower is tilted out by the deltoid. When the break is below the deltoid insertion the displacement of the fragments is reversed. Undue mobility, deformity, crepitus, and the other signs of fracture are evident, and the patient himself usually recognises that the bone is broken. Union takes place in from four to six weeks in adults, and in from three to four weeks in children. Delayed union, or want of union and the formation of a false joint, is more common in fractures of the middle of the shaft of the humerus than in any other long bone. This is largely due to the frequency with which soft structures pass between the ends of the bone. Arrest of growth in the bone from injury to the nutrient medullary artery is also said to have occurred. In fractures of the lower part of the shaft the musculo-spiral nerve is specially liable to be implicated. This may occur at the time of the injury, the nerve being contused by the force causing the fracture, or pressed upon by one or other of the fragments, or its fibres may be partially or completely torn across. Later it may become involved in callus, or damaged by the pressure of ill-fitting splints. Weakness or paralysis of the extensors of the wrist and hand results, giving rise to the characteristic "wrist-drop." The actions of the extensors should always be tested before applying splints, and each time the apparatus is removed or readjusted, to ensure that no undue pressure is being exerted on the nerve. In this way the practitioner will guard himself against actions for malpraxis should paralysis of the muscles ensue. The median and ulnar nerves may also be damaged.

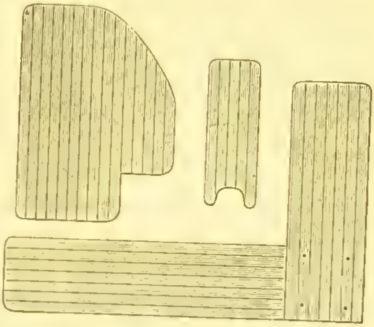

FIG. 106.—Gooch Splints for Fracture of Shaft of Humerus.

Treatment.—In treating a fracture of the shaft of the humerus the possibility of non-union should always be kept in mind. Reduction must be completely effected, by the aid of a general anæsthetic if necessary, care being taken that no soft tissue intervenes between the fragments. The appearances seen with the X-rays may yield information on this point. The local splint to control the fracture is applied in the form of a ferrule surrounding the bone. This may consist of several short, narrow pieces of wood secured by a bandage or strap and buckle; or better, of two pieces of Gooch splinting cut as in Fig. 106, special provision being made for avoiding pressure on the condyles. The elbow is flexed to a right angle, the forearm being midway between pronation and supination, and the forearm is supported in a sling. For a few days the shoulder may be controlled by a shoulder-cap, or by binding the limb to the chest by a wide roller bandage.

Massage and movement are carried out from the second week onward. The patient should be allowed to use the fingers, wrist and forearm to some extent.

In oblique fractures, when there is difficulty in preventing overriding and redisplacement, the fragments may be exposed by incision, and fixed to each other by mechanical means.

When there is evidence that the musculo-spiral nerve has been injured, and no sign of improvement appears within three or four days, operative interference is indicated. An incision is made on the outer side of the arm, exposing the nerve, which is then freed from pressure by fragments or callus; or if torn across, the nerve should be stitched. In cases of old standing it has been found necessary to resect a portion of the shaft of the humerus to enable the ends of the nerve to be approximated. The opportunity should also be taken of dealing with the fracture as may be necessary.

In cases of *ununited fracture* a vertical or semilunar incision is made over the outer aspect of the bone, and the muscles separated from one another till the fracture is exposed, care being taken to avoid injuring the musculo-spiral nerve. The ends of the bone are refreshed by removing the fibrous tissue which covers them, and the rawed surfaces fixed in apposition by pegs, screws, or wires. The wound is then closed, and appropriate splints and other retentive apparatus applied. As soon as the wound has healed massage is commenced.

CHAPTER XXIII.

INJURIES IN THE REGION OF THE ELBOW AND FOREARM.

Surgical Anatomy — Examination of injured elbow — FRACTURES OF LOWER END OF HUMERUS: *Supra-condylar; Inter-condylar; Separation of epiphysis; Fracture of either condyle alone; Fracture of either epicondyle alone*—FRACTURES OF UPPER END OF ULNA: *Olecranon; Coronoid*—FRACTURES OF UPPER END OF RADIUS: *Head; Neck; Separation of epiphysis*—DISLOCATIONS OF ELBOW: *Both bones; Ulna alone; Radius alone*—FRACTURES OF FOREARM: *Both bones; Radius alone; Ulna alone.*

THE injuries met with in the region of the elbow-joint include the various fractures of the lower end of the humerus, and upper ends of the bones of the forearm, including the olecranon process; and dislocations and sprains of the elbow-joint. The differential diagnosis is often exceedingly difficult, on account of the great swelling and tension which rapidly supervene on most of these injuries, the pain caused by manipulating the parts, and the difficulty of determining with certainty whether movement is taking place *at* the joint or *near* it.

Surgical Anatomy.—The internal epicondyle of the humerus is more readily felt through the skin than the external. They lie practically on the same level. A line joining the two epicondyles behind, passes just above the tip of the olecranon process when the arm is fully extended. On flexing the joint the tip of the olecranon gradually passes to the distal side of this line. The head of the radius can be felt to rotate during pronation and supination in the dimple which exists on the back of the elbow just below the external condyle. The coronoid process may be detected on making deep pressure in the hollow in front of the joint. The upper arm forms with the fully extended and supinated forearm an obtuse angle, opening outward—the "carrying angle." This angle is usually more marked in women, in harmony with the greater width of the female pelvis. The ulnar nerve lies in the hollow between the olecranon and the internal condyle, and the median nerve passes over the front of the joint, with the brachial artery and biceps tendon to its outer side. The musculo-spiral nerve divides into its radial and posterior interosseous branches at the level of the outer condyle.

In *examining an injured elbow* the thumb and middle finger are placed respectively on the two epicondyles, while the index locates the olecranon and traces its movements on flexion and extension of the joint. The movements of the head of the radius are best detected by pressing the thumb of one hand into the depression below the external condyle, while passive movements of pronation and supination are carried out by the other hand. The uninjured limb should always be examined for purposes of comparison.

In the more obscure forms of injury much aid in diagnosis is often obtained from a radiogram, which, in cases of suspected fracture, should be taken with the back of the limb resting on the sensitive plate, the forearm being extended and supinated. If a dislocation is suspected and a lateral view be desired, the arm should be placed on its inner side. It is useful to take radiograms of the healthy limb in the same position.

FRACTURES OF THE LOWER END OF THE HUMERUS.

The following fractures may occur at the lower end of the humerus: (1) supra-condylar fracture; (2) inter-condylar fracture; (3) separation of epiphyses; (4) fracture of either condyle alone; and (5) fracture of either epicondyle alone.

All these injuries are very common in children, and may result from a direct fall or blow upon the elbow, or from a fall on the outstretched hand, especially when at the same time the joints are forcibly moved beyond their physiological limits, more particularly in the direction of pronation or abduction. While it is generally easy to diagnose the existence of a fracture, it is often exceedingly difficult to determine its exact nature. Although the ulnar and median nerves are liable to be injured in almost any of these fractures, they suffer much less frequently than might be expected.

Ankylosis, or, more frequently, locking of the joint, is a common sequel to many of these injuries. This is explained by the difficulty of effecting complete reduction, and by the wide separation of periosteum which often occurs, favouring the production of an excessive amount of callus, particularly in young subjects.

The **supra-condylar** fracture usually results from a fall on the outstretched hand with the forearm partly flexed, from a direct blow, or from a twisting form of violence. The line of fracture is generally transverse, or but slightly oblique from behind downwards and forwards, so that the lower fragment is forced backward together with the bones of the forearm, simulating a backward dislocation of the elbow. The lower end of the upper fragment lies in front of the elbow.

Clinical Features.—The elbow is flexed at an angle of 120° or 130°, and the forearm, held semi-pronated, is supported by the other hand. The olecranon projects behind, but the mutual relations of the bony points of the elbow are unaltered. The lower end of the upper fragment may be felt in front above the level of the joint, as a rough and sharp projection which sometimes pierces the soft parts and renders the fracture compound. The joint movements are normal, but unnatural mobility may be detected above the level of the joint. The displacement is readily reduced by manipulation, but is usually reproduced when the support is withdrawn. The upper arm is shortened to the extent of about half an inch. Great swelling around the seat of fracture rapidly ensues, and crepitus and localised tenderness may be elicited.

In rare cases the obliquity of the fracture is downward and backward, and the lower fragment is displaced forward.

The **inter-condylar** fracture is a combination of the supra-condylar with a vertical split running through the articular surface, and so implicating the joint (Fig. 107). The condyles are thus separated from one another as well as from the shaft by a T- or Y-shaped cleft. As such fractures usually result from severe forms of direct violence, they are often comminuted and compound. In addition to the signs of supra-condylar fracture, the cavity of the joint is filled with blood. The condyles may be felt to move upon one another, and coarse crepitus, which has been likened to the feeling of a bag of beans, may be elicited if the fragments are comminuted.

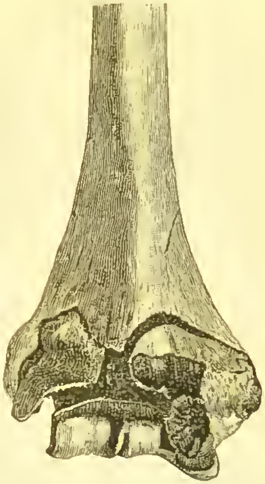

Fig. 107. — Inter-condylar Fracture of Lower End of Humerus. from a crush between buffers, in a man aet. 19.

Separation of the lower epiphysis of the humerus is a comparatively frequent injury in children of three or four years of age. It may occur up to the thirteenth or fourteenth year, but beyond that age the lesion is usually a combination of separated epiphysis with true fracture. This lesion is produced by the same forms of violence as cause supra-condylar fracture. If the periosteum is not torn there is little or no displacement, but as a rule the clinical features closely resemble those of transverse fracture above the condyles. In separation of the epiphysis there is a peculiar deformity of the posterior aspect of the joint, consisting of two projections — one the olecranon process, and the other the prominent capitellum with a scale of cartilage which it carries with it from the external condyle (R. W. Smith and E. H. Bennett). The smooth rounded end of the diaphysis may sometimes be palpated through the skin in front. Muffled crepitus can usually be elicited, and there is pain on pressing the segments against one another.

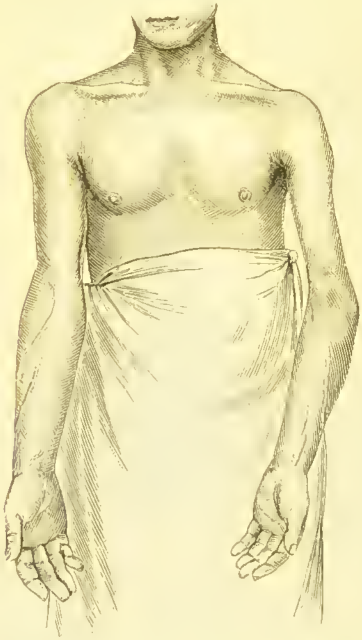

FIG. 108.—Cubitus Varus resulting from Fracture of Internal Condyle of Humerus in childhood. Note imperfect development of upper arm.

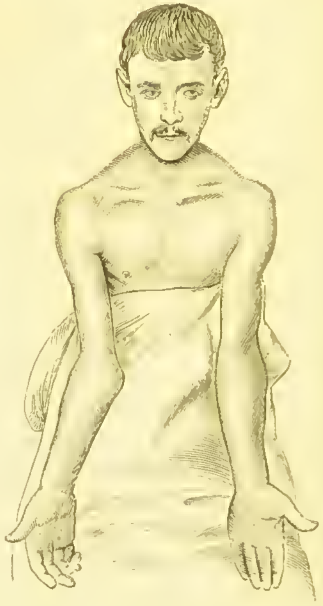

FIG. 109.—Cubitus Valgus resulting from Fracture of External Condyle in childhood.

Union takes place more rapidly than in true fracture, but owing to the excessive formation of callus from the torn periosteum in front of the joint, full flexion is often interfered with. If the displaced epiphysis is imperfectly reduced, serious interference with the function of the elbow is liable to result, and may even call for operative interference.

Fracture of either Condyle alone.—The *internal* condyle is more frequently separated from the rest of the bone than is the external. In either case the size of the fragment varies, but the line of fracture is always partly extra-capsular and partly intra-capsular, so that the joint is always involved. Undue mobility, pain, crepitus, and the other signs of fracture are present. As the ulna and radius remain attached to the respective fragments by their ligaments, which are intact, there is little or no immediate displacement. Secondary displacement is liable to occur, however, during the process of union, producing alterations in the "carrying angle" of the limb—*cubitus varus* or *valgus*.

Fracture of the *external epicondyle* alone is so rare that it need not be further referred to.

The *internal epicondyle* may be chipped off by a fall on the edge of a table or kerb-stone, or may be forcibly avulsed by traction through the internal lateral ligament as an accompaniment of dislocation. It is usually displaced downwards and forwards by the flexor muscles attached to it, and may thus come to exert injurious pressure on the ulnar nerve. The fragment may be grasped and made to move on the shaft, producing crepitus. Fibrous union is the usual result.

Up to the age of seventeen or eighteen the corresponding epiphysis may be separated.

Treatment of Fractures in region of Elbow.—It has already been mentioned that a general anæsthetic is necessary for the diagnosis of fractures in this region. It is no less essential as an aid to accurate reduction and fixation. Much discussion has taken place as to the best position in which to treat these fractures, and the consensus of opinion seems now strongly to favour that of full flexion of the elbow. Clinical experience is supported in this view by the evidence afforded by the Röntgen rays. In no other position of the joint can the fragments be brought into such accurate apposition.

In all cases the early employment of massage and movement is necessary to avoid the risk of stiffness and diminished range of motion.

The *supra-condylar fracture* is reduced by first extending the elbow to free the lower fragment from the triceps, and then making traction through the forearm and manipulating the fragments into position, and finally fully flexing the elbow. In this way the triceps is put upon the stretch and forms a natural posterior splint. A pad is placed in the bend of the elbow to separate the opposed skin surfaces. The elbow is fixed in this position by means of a figure-of-eight bandage, supplemented by a posterior, gutter-shaped splint of poroplastic, or by a modification of Croft's splint placed along each side of the limb. The arm is placed in a sling and fixed to the side by a roller bandage. Movement and massage should be begun in two or three days, great care being taken that the fragments are not redisplaced. By the end of a week the angle at which the elbow is fixed may be gradually increased. The splint should be worn for about three weeks, and a sling for a week or two longer.

Separation of the epiphysis and *fracture of the internal epicondyle* are treated on the same general lines. It is, however, sometimes necessary in the latter fracture to fix the small fragment in position by a nail inserted through the skin.

T- or Y-*shaped fractures* and *fractures of the condyles*, inasmuch as they implicate the articular surfaces, present greater difficulties in treatment. In young subjects whose occupation entails free movement of the elbow-joint, it is generally advisable to expose the fracture by operation and secure the fragments in position by nails or wires. The details of the operation vary with each case, depending upon the line of obliquity of the fracture, and the disposition of the individual fragments. Information regarding these points may usually be derived from radiograms. In performing the operation care must be taken to disturb the periosteum of the fragments as little as possible, lest their nutrition be interfered with. In less complicated cases it is sometimes possible to fix the fragments in apposition by nails inserted through the skin without an open incision. After operation a retentive apparatus similar to that employed for the supra-condylar fracture is applied, and the after treatment is conducted on the same lines.

Operative interference is sometimes necessary for ankylosis or locking of the joint after fracture, or to relieve the ulnar nerve when it is involved in callus.

Fractures of the Upper End of the Ulna.

Fracture of the olecranon process is a comparatively common injury in adults. It usually follows a fall on the flexed elbow, and is believed to result from the direct impact, supplemented by the traction of the triceps muscle. In a few cases it has been produced by muscular action alone. The line of fracture usually passes through the tip of the process, less frequently through its middle, and but rarely through the base. It may be transverse, oblique, T- or V-shaped, but is rarely comminuted or compound.

Clinical Features.—As the fracture almost invariably implicates the articular surface of the bone, there is considerable swelling from effusion of blood into the joint. The power of extending the forearm is impaired, and other symptoms of fracture are present. The amount of displacement depends upon the level of the fracture, and the extent to which the aponeurotic expansion of the triceps is torn. As the fracture is usually near the tip the displacement is generally comparatively slight, the prolongation of the fibres of insertion of the triceps on to the lateral and posterior parts of the process holding the small fragment in position. When the line of fracture is nearer the base, however, the contraction of the triceps tends to separate the fragments widely, and a distinct gap, which is increased on flexing the elbow, may often be felt between them. The upper fragment may be palpated; and if the elbow be passively extended, the fragments may be brought into apposition, and crepitus elicited. The upper fragment sometimes forms attachments to the shaft of the humerus, and this leads to stretching of the fibrous band between the fragments.

When the fracture is oblique and there is little displacement bony union may result. In many cases the fragments are united by fibrous tissue.

Treatment.—Within recent years the tendency of surgical opinion has been towards operative treatment in fracture of the olecranon, particularly where there is marked separation of the fragments in the case of young adults.

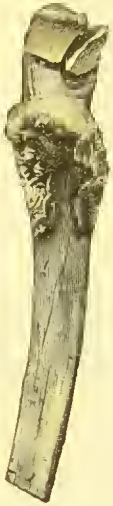

FIG. 110.—T-shaped Fracture of Olecranon Process.

It is still an open question, however, whether the results after operation are better than those obtained by one or other of the non-operative measures to be described. It would appear that too much stress has been laid on the necessity of fixing the fragments in accurate apposition, and that too little attention has been paid to the importance of massage and movement in maintaining the functions of the muscles and of the joint.

Treatment by Apparatus.—When the fracture passes through the tip of the process, and there is little or no displacement, the application of a convergent spica bandage to the elbow, a rectangular splint, and a sling fulfil all requirements.

When the displacement is considerable, however, the arm should be almost, but not quite, fully extended, and a bandage applied from the fingers to the level of the axillary fold, the turns covering the elbow being applied in the form of a convergent spica to approximate the fragments. A Gooch splint, extending from the lower border of the axilla to the finger tips, and cut to the shape of the extended limb (Fig. 111), is then applied anteriorly and fixed in position by a bandage, the region of the elbow being again covered in by a convergent spica.

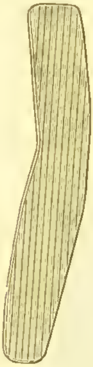

FIG. 111.—Gooch Splint for Fracture of Olecranon. Note "carrying angle."

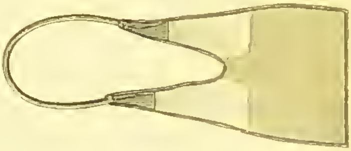

FIG. 112.—Horse-shoe-shaped Adhesive Plaster, with Elastic Tubing for Fracture of Olecranon.

When the displacement is great, the fragments may be approximated by fixing a horse-shoe-shaped piece of adhesive plaster (Fig. 112) to the back of the arm so that it embraces the upper fragment, and attaching to it a piece of strong elastic tubing, to be fixed to the lower end of the anterior splint, which must be made to project an inch or two beyond the tips of the fingers (Fig. 113). Another method is to fix the elastic to the cuff of a strong dogskin glove applied to the hand.

The apparatus must be worn for about a month, massage and movement being commenced during the course of the first week; great care is necessary to avoid separation of the fragments while this is being done. When the fracture has been treated by prolonged immobilisation, and massage has not been employed, stiffness of the joint frequently persists for a considerable time.

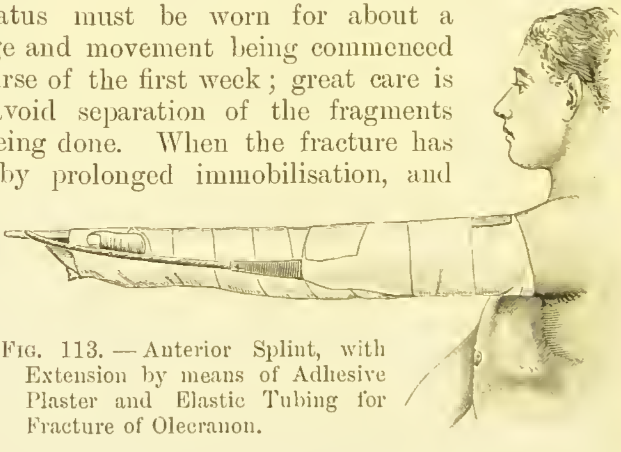

FIG. 113.—Anterior Splint, with Extension by means of Adhesive Plaster and Elastic Tubing for Fracture of Olecranon.

Operative Treatment.—A semilunar incision with its base above the tip of the olecranon is carried through the skin and fascia. The fracture is exposed, the joint cavity opened up and cleared of clots, and silver-wire or fishing-gut sutures passed through the fragments without encroaching upon the articular cartilage. The limb is fixed with a splint with the elbow-joint slightly extended. Movement may be commenced in the course of a few days, the angle at which the joint is fixed being changed each day. The patient is allowed to use the joint cautiously within a fortnight.

Old-standing Fractures.—When firm union fails to take place the interval between the fragments tends to increase by the contraction of the triceps gradually stretching the intermediate fibrous tissue, so that a wide gap comes to separate the fragments, and the function of the limb is impaired. The best treatment in such cases is to expose the fragments, refresh their edges, and wire them, and if necessary the triceps is lengthened.

Fracture of the coronoid process is very rare except as a complication of backward dislocation of the elbow. It may be produced, however, by direct violence as well as by muscular action. As the fracture is usually within a quarter of an inch of the tip, the fibres of insertion of the brachialis anticus tend to prevent displacement. In some cases associated with dislocation, however, the small fragment has been so far displaced as to become attached to the back of the condyles of the humerus (Annandale). The ordinary evidences of fracture are seldom present, and the diagnosis is often uncertain. Uncomplicated cases are treated by flexion of the elbow and a sling.

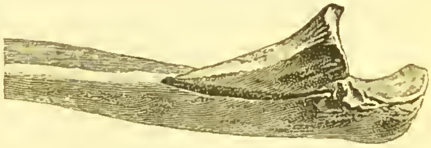

FIG. 114.—Fracture of Coronoid Process.

FRACTURES OF THE UPPER END OF THE RADIUS.

Intra-capsular fracture of the *head of the radius* may result from direct violence, a fall on the pronated hand, or from forcible pronation or abduction. It may accompany dislocations of the elbow or fracture of adjacent bones. The head may be completely separated, or may be split into two or more fragments.

The *clinical features* are localised pain, crepitus, interference with pronation and supination, and in some cases the fragment may be felt through the skin, although it usually continues to move with the shaft in pronation and supination.

Union generally takes place satisfactorily, but in some cases the fragments form new attachments resulting in impaired movement of the joint.

Fracture of the *neck of the radius* between the capsule and the tubercle is extremely rare, as is also *separation of the upper epiphysis.* These injuries are treated in the flexed position, and massage and movement are carried out as already described.

DISLOCATIONS OF THE ELBOW.

Dislocations of the elbow-joint may involve one or both bones of the forearm, and the separation may be complete or incomplete.

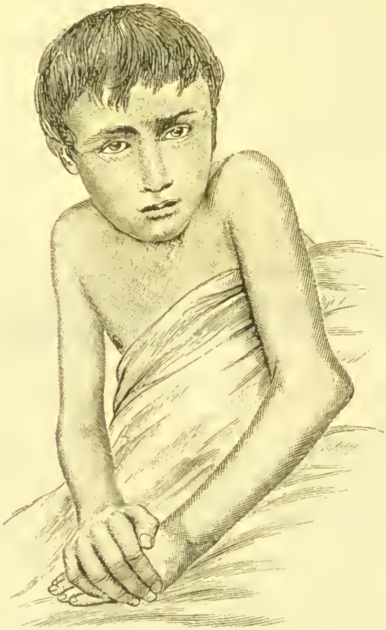

FIG. 115. — Backward Dislocation of Elbow, in a boy aet. 10, caused by a fall off a wall, landing on the elbow.

Dislocation of both bones backward is the most common of all dislocations of the elbow, and is the only dislocation in the body which is frequently met with in children. It usually results from a fall on the outstretched hand, causing hyper-extension and abduction of the joint—that is, lateral deviation towards the radial side; but it may follow a direct blow on the back of the humerus, a fall on the elbow, or a twist of the forearm.

Morbid Anatomy.—The anterior and lateral ligaments of the elbow are torn, while the posterior and orbicular ligaments remain intact. The radius and ulna pass back, the coronoid process coming to rest opposite the olecranon fossa behind the humerus, and the head of the radius behind the external condyle. The condyles of the humerus bear their normal relations to one another. The olecranon process and triceps tendon form a marked prominence on the back of the elbow, the tip of the olecranon lying above and behind the condyles. The lower end of the humerus lies in the flexure of the joint with the biceps tendon tightly stretched over it. The coronoid process is often broken, or the tendon of the brachialis anticus torn. The median and ulnar nerves are generally stretched and may even be torn. Not infrequently the bones of the forearm are displaced towards the inner side as well as backward (Fig. 116).

Clinical Features.—The elbow is held fixed at an angle of about 120°, pronated or midway between pronation and supination. Any attempt at movement causes great pain, and is followed by an elastic rebound to the abnormal position. The antero-posterior diameter of the joint is increased, and the forearm, as measured from the external condyle to the tip of the styloid process of the radius, is shortened to the extent of about an inch. If examined before swelling ensues the outlines of the articular surfaces may be recognised in their abnormal positions. Great swelling usually comes on rapidly, and, by obscuring the bony landmarks of the joint, renders the diagnosis difficult.

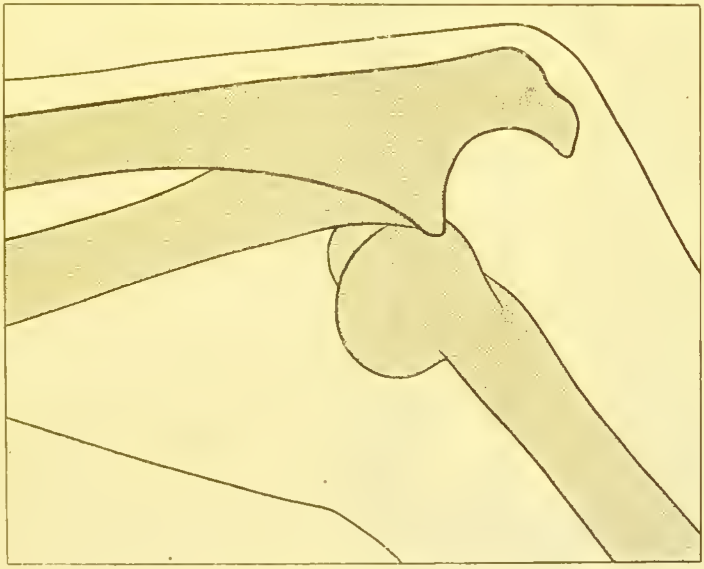

Fig. 116.—Tracing of Radiogram of Incomplete Backward and Inward Dislocation of Elbow.

This injury has to be diagnosed from supra-condylar fracture with backward displacement, and from separation of the lower humeral epiphysis. A general anaesthetic is often necessary to enable an accurate diagnosis to be made. When the deformity is once reduced, there is no tendency to its reproduction unless the coronoid process is at the same time fractured.

In a considerable number of cases—according to E. H. Bennett, in the majority—this dislocation is *incomplete*, the coronoid process resting at the level of the trochlea, and the backward projection of the olecranon being scarcely appreciable. The head of the radius, however, is unduly prominent. In such cases the lesion is liable to be overlooked, and therefore to go untreated, leading to permanent impairment of function of the joint.

Dislocation forward is much less common than the backward variety. It is produced by severe force acting from behind on the flexed elbow, the ulna being driven forward, tearing the ligaments of the joint and the muscles attached to the condyles. The olecranon process is frequently fractured at the same time. When it remains intact it may rest below the condyles (incomplete or first stage of dislocation), or may pass in front of them, especially if the triceps be ruptured (complete or second stage). The forearm is lengthened, the elbow slightly flexed, the posterior aspect of the joint flattened, and the condyles and olecranon, in their abnormal relationship, can be palpated from behind.

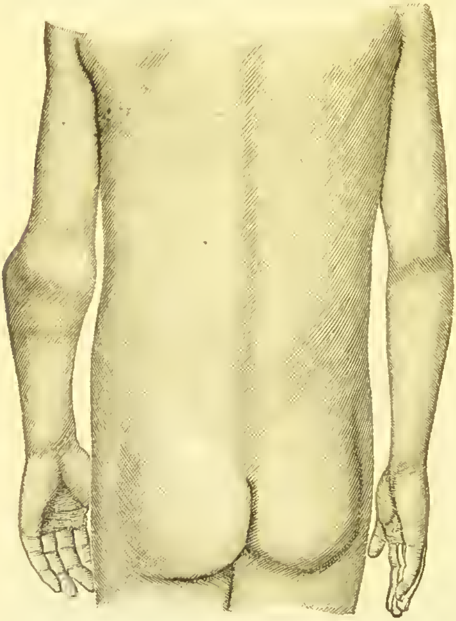

Fig. 117.—Backward and Outward Dislocation of Left Elbow, in a boy aet. 10.

Lateral Dislocations.—Dislocation towards the ulnar side—*inward*—is always incomplete, some portion of the articular surface of the bones of the forearm remaining in contact with the condyles.

The radial or *outward* dislocation is also incomplete as a rule, although cases have been recorded in which complete separation had taken place.

Both forms of lateral dislocation are rare, the inward variety being that more frequently observed. Each form is often combined with other injuries in the region of the joint.

The most common cause of these dislocations is a fall on the outstretched hand, the forearm at the moment being strongly pronated. Forced abduction favours the inward displacement, adduction the outward. The limb is held flexed and pronated, and the facility with which the bony points can be palpated renders the diagnosis easy.

In a few rare cases *diverging dislocations* have been met with, the radius and ulna passing away from one another, either antero-posteriorly or laterally.

Treatment.—The chief obstacles to reduction in the *backward and lateral dislocations* are the spasmodic contraction of the muscles passing over the joint, and sometimes the hitching of the coronoid process against the edge of the olecranon fossa. In recent cases reduction can usually be effected with comparative ease if the patient be seated on a chair, while the surgeon grasps the humerus and wrist, and places his knee in the bend of the elbow. The limb is first fully extended, or even hyper-extended, to relax the triceps and free the coronoid process. Traction is next made in opposite directions upon the forearm and upper arm, the surgeon's knee meanwhile making pressure, in a backward direction, upon the lower end of the humerus. The joint is then slowly flexed, and the bones slip into position, often with a distinct snap. If the patient be anæsthetised these manipulations must be adapted to the recumbent position. When some days have elapsed before reduction is attempted, adhesions must be broken down by flexing, extending, and laterally moving the joint, under an anæsthetic, before the manipulations are carried out.

The limb is flexed to rather less than a right angle, fixed in a posterior moulded splint, and supported by a sling. Massage and movement are commenced in a day or two, and the splint is worn for two or three weeks.

Fracture of the coronoid process predisposes to recurrence of the dislocation; when this complication exists, therefore, the limb should be fixed at an acute angle, and movements postponed for a fortnight. Massage, however, may be carried out after the first few days.

If fracture of the olecranon process complicates the dislocation, after reduction, the limb must be treated in the extended position, with an anterior splint and extension as already described.

Comminuted and compound injuries usually call for operative treatment, the fractured bones being wired after reduction of the dislocation, or the loose fragments removed.

The *forward dislocation* is reduced by fully flexing the elbow, and then pushing the bones of the forearm backward, while the humerus is pulled forward.

Old-standing Dislocations.—It is seldom possible to reduce by manipulation a dislocation of the elbow which has remained displaced for five or six weeks, especially when it has been complicated by a fracture. The joint surfaces become welded together by adhesions, and separated fragments often form attachments which completely lock the joint. Attempts to break these down are attended with considerable risk of refracturing the bone or of tearing soft parts. In such cases it is best to expose the joint by incision and to remove sufficient bone to provide a movable and useful joint.

Dislocation of the ulna alone is a very rare injury, and is usually associated with fracture of one or other of its processes or of the internal condyle.

Dislocation of the radius alone, on the other hand, is comparatively common, especially as a concomitant of fracture of the upper third of the shaft of the ulna.

The injury may result from a blow on the back of the upper end of the radius, a fall on the outstretched hand, or, in children, from forcibly dragging the forearm while in the pronated position. The displaced head usually passes *forward*, and rests on the anterior edge of the capitellum, thus preventing complete flexion and supination of the limb.

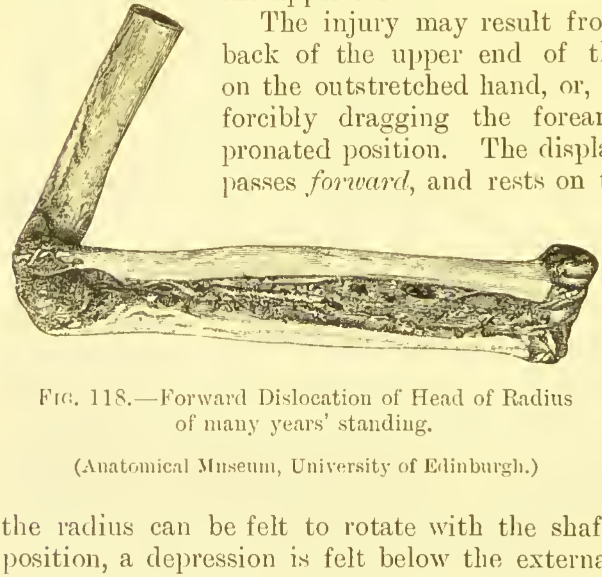

FIG. 118.—Forward Dislocation of Head of Radius of many years' standing.

(Anatomical Museum, University of Edinburgh.)

The limb is flexed and pronated. The displaced head of the radius can be felt to rotate with the shaft in its abnormal position, a depression is felt below the external condyle, where the head should be, and the cup-shaped depression on the head of the radius may also be felt. The radial side of the forearm is slightly shortened.

In a few cases the displacement of the head has been *backward* or *outward*.

Treatment.—To effect reduction the forearm should be flexed and supinated, while traction is made upon it from the wrist. At the same time the lower end of the humerus and the head of the radius are pressed backward. When reduction is prevented by the interposition of a portion of the torn ligaments between the bones, it is sometimes necessary to open the joint to ensure accurate adjustment. The joint is fixed in acute flexion by a posterior moulded splint for about three weeks, to allow of union of the torn ligaments and to prevent recurrence.

In old-standing cases, to obtain a useful joint, resection of the head of the radius is often necessary.

Sub-luxation of the head of the radius, or "dislocation by elongation," is a comparatively common injury in children between the ages of two and six. It almost invariably results from the child being lifted or dragged by the hand or forearm. The traction and torsion thus put upon the radius causes the front part of its head to pass out of the orbicular ligament, the edge of which slips between the bones.

The person holding the child may feel a click at the moment of displacement. The child complains of pain in the region of the elbow; the arm at once becomes useless, and is held flexed, midway between pronation and supination. All movements are painful, but especially movements in the direction of supination. The deformity is slight, but the head of the radius may be unduly prominent in front. From the way in which the injury is produced the wrist also is often swollen, being injured at the same time, and in some cases the patient is brought to the surgeon on account of the condition of the wrist.

Treatment.—Spontaneous reduction frequently takes place, the function of the arm being at once completely restored. In other cases it is necessary, under anæsthesia, to manipulate the head of the bone into position. This is usually easily done by flexing the elbow, making slight traction on the forearm, and alternately pronating and supinating it. A few days' massage is all that is necessary, the joint in the intervals being kept at rest in a splint and sling.

Sprains of the elbow are comparatively common as a result of a fall on the hand or a twist of the forearm. The point of maximum tenderness is usually over the radio-humeral joint, the external lateral and orbicular ligaments being those most frequently stretched or torn. Effusion takes place into the synovial cavity, and a soft, puffy swelling fills up the natural hollows about the joint. The bony points about the elbow retain their normal relationship to one another—a feature which aids in determining the diagnosis between a sprain and a dislocation or fracture in this region. In children it is often very difficult to distinguish between a sprain and the partial separation of an epiphysis. Sprains of the elbow are treated on the same lines as similar lesions elsewhere—by massage and movement. The condition known as *tennis elbow* is characterised by severe pain over the insertion of the pronator radii teres during the act of pronation, and is due to stretching or tearing of the fibres of that tendon, and of the adjacent intermuscular septa. A similar injury—*sculler's sprain*—occurs in rowing men from feathering their oars. The treatment consists in massage and movement, care being taken to avoid the movements which produced the injury. In persistent cases blistering may be useful.

FRACTURES OF THE FOREARM.

The *shafts* of the bones of the forearm may be broken separately, but it is much more common to find both broken together.

Fracture of both bones may result from a direct blow, a fall on the hand, or from their being bent over a fixed object. The line of fracture is usually transverse, both bones giving way about the same level. The common situation is near the middle of the shafts. In children greenstick fracture of both bones is a very frequent result of a fall on the hand—this indeed being one of the commonest examples of greenstick fracture met with.

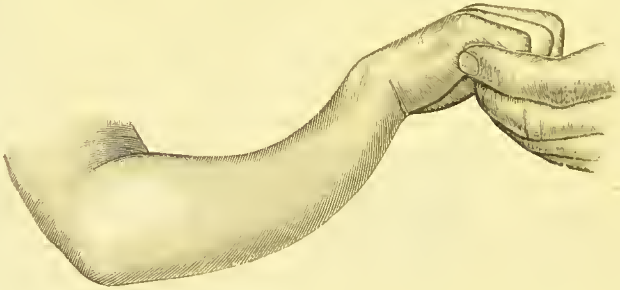

FIG. 119.—Greenstick Fracture of both Bones of the Forearm.

The *displacement* in complete fractures varies widely, depending partly upon the force causing the fracture, partly on the level at which the bones break and on the muscles which act on the respective fragments. It is common to find an angular displacement of both bones to the radial or to the ulnar side. In other cases the four broken ends impinge upon the interosseous space, and may become united to one another, preventing the movements of pronation and supination. There may be shortening from overriding of fragments.

When the radius is broken above the insertion of the pronator radii teres, its upper fragment may be supinated by the biceps and supinator brevis, while the lower fragment remains in the usual semi-prone position. If union takes place in this position the power of complete supination is permanently lost.

The usual *symptoms* of fracture are present, and there is seldom any difficulty in diagnosis.

The *prognosis* must be guarded, especially with regard to the preservation of pronation and supination. These movements may be interfered with if union takes place in a bad position with angular or rotatory deformity of one or both bones, or by excessive callus formation leading to locking of the bones.

Persistent angular deformity of the forearm is also liable to result, either from failure to correct the displacement primarily, or from subsequent bending due to ill-applied splints or slings. Want of union, or the formation of a false joint in one or both bones, is sometimes met with, and seriously impairs the usefulness of the limb.

A considerable number of cases of gangrene of the limb after simple fracture of the forearm are on record. This is sometimes attributable to damage inflicted upon the blood-vessels by the fractured bones, or to the force which caused the fracture, but is oftener due to the application of a roller bandage underneath the splints strangulating the limb, to injudiciously applied pads, or to too tight bandaging over the splints.

In uncomplicated cases union takes place in from three to four weeks.

Treatment.—To ensure accurate reduction and coaptation a general anæsthetic is usually necessary. In the greenstick variety the bones must be forcibly straightened, the fracture being rendered complete, if necessary, for this purpose.

The most convenient apparatus for the retention of the fracture consists of Gooch splints, cut so as to overlap the forearm by about half an inch on each side, to avoid lateral compression of the forearm whereby the fractured ends are made to encroach upon the interosseous space. The dorsal splint is usually made to extend from the olecranon to the knuckles, and the palmar one from the bend of the elbow to the flexure in the middle of the palm, a piece being cut out to avoid pressure on the ball of the thumb (Fig. 120). The splints are padded, and applied with the wooden side next the limb, so that they form two sides of a box, the other sides being formed by the retaining bandage. The splints are applied with the elbow flexed to a right angle, and, except when the radius is broken above the level of the insertion of the pronator radii teres, with the forearm midway between pronation and supination. An external rectangular splint is then applied, and the limb supported by a sling, so adjusted that it supports equally the hand and elbow, in order to avoid angular deformity. Tight bandaging and the use of special interosseous pads are to be avoided, as they are liable to cause gangrene.

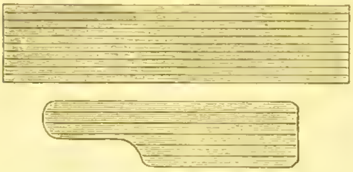
Fig. 120.—Gooch Splints for Fracture of both Bones of Forearm.

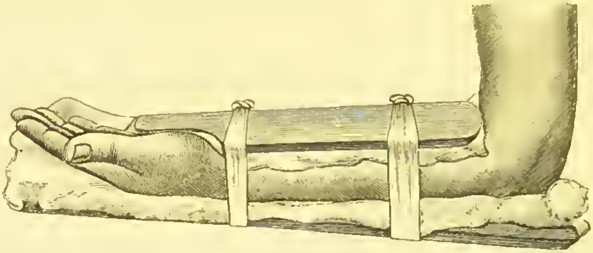
Fig. 121.—Gooch Splints for Fracture of Forearm applied.

When the fracture of the radius is above the insertion of the pronator radii teres, the forearm should be fixed in the position of complete supination, with the elbow flexed to an acute angle, and retained in this position by moulded anterior and posterior splints. This position is very irksome to the patient, and great care is necessary in the adjustment of the apparatus to prevent pronation.

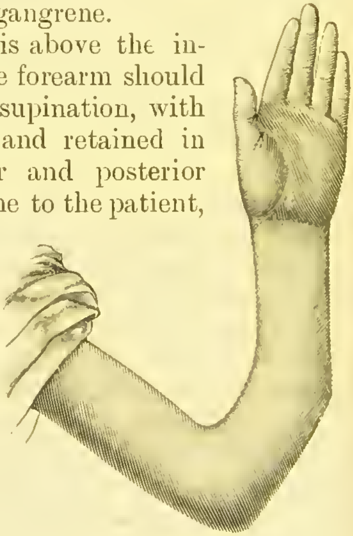
Fig. 122.—Badly united Fracture of both Bones of Forearm. Boy aet. 11. Probably an unreduced greenstick fracture.

Massage and movement should be carried out early. It is usually necessary to continue wearing the splints for about four weeks.

In cases of *mal-union*, especially when the bones are ankylosed to one another across the interosseous space, an operation may be necessary, but it is neither easy in its performance nor always satisfactory in its results. The seat of fracture should be exposed by one or more incisions so placed as to enable the muscles to be separated and give access to the callus. When the limb is straight it is only necessary to gouge away the exuberant callus which interferes with rotatory movements; but when there is an angular deformity (Fig. 122) the bones must, in addition, be divided and reset, and, if necessary, wired in good position. In recent cases it is sometimes possible forcibly to re-fracture the bones, and to set them anew without operation.

Ununited fracture of the bones of the forearm is treated on the usual lines.

Fracture of the shaft of the radius alone may be due to a direct blow, to a fall on the hand, or to forcible pronation against resistance, as in wringing clothes. It is rare in comparison with fracture of both bones. When broken above the insertion of the pronator radii teres, the upper fragment is flexed and supinated by the biceps and supinator brevis, while the lower fragment remains semi-prone, and is drawn towards the ulna by the pronator quadratus.

When the fracture is below the pronator radii teres the displacement depends upon the direction of the force and the obliquity of the fracture. In fractures of the lower third of the shaft the hand may be flexed toward the radial side, raising the styloid process, and so simulating a Colles' fracture.

In addition to the ordinary signs of fracture, there is loss of complete pronation and supination. The head of the radius as a rule does not move with the lower part of the shaft, but may do so if the fracture is incomplete or impacted.

Fracture of the shaft of the ulna alone is also comparatively rare. It is almost always due to a direct blow sustained while protecting the head from a stroke, or to a fall on the ulnar edge of the forearm.

The upper third is most frequently broken, and this injury is often associated with dislocation of the head of the radius, or some other injury implicating the elbow-joint. On account of the superficial position of the bone this fracture is frequently compound.

The displacement depends on the direction of the force, the fragments being usually driven towards the interosseous space. There is seldom marked deformity unless the head of the radius is dislocated at the same time. The diagnosis is, as a rule, easy.

The *treatment* is the same as for fracture of both bones, but the splints may be dispensed with at the end of a fortnight or three weeks.

CHAPTER XXIV.

INJURIES IN THE REGION OF THE WRIST AND HAND.

Surgical Anatomy—FRACTURES OF LOWER END OF RADIUS: *Colles' fracture; Smith's fracture; Longitudinal fracture; Separation of epiphysis*—FRACTURES OF LOWER END OF ULNA: *Shaft; Styloid process; Separation of epiphysis*—FRACTURES OF CARPAL BONES—DISLOCATIONS: *Inferior radio-ulnar joint; Radio-carpal joint; Carpal bones; Carpo-metacarpal joint*—SPRAINS.

INJURIES IN THE REGION OF THE WRIST.

THESE include fractures of the lower ends of one or both bones of the forearm, or separation of their epiphyses; dislocations and sprains of the inferior radio-ulnar, and of the radio-carpal articulations; and fractures and dislocations of the carpus.

Surgical Anatomy.—The most important landmarks in the region of the wrist are the styloid processes of the radius and ulna. The tip of the radial styloid is palpable in the "anatomical snuff-box" between the tendons of the extensor brevis and extensor longus pollicis, and lies about half an inch lower than the ulnar styloid. The ulnar styloid is best recognised on making deep pressure a little below and in front of the head of the ulna, which forms the rounded subcutaneous prominence seen on the back of the wrist when the hand is pronated.

The tubercle of the scaphoid and the trapezium can be felt at the base of the ball of the thumb, a little below the radial styloid; while the pisiform and hook of the unciform are palpable, slightly below and in front of the ulnar styloid.

In examining an injured wrist the different bony points should be located, and their relative positions to one another and to the adjacent joints noted. The particular shape, position, and relations of any unnatural projection or depression should likewise be carefully observed. The power and range of movement—active and passive—at the various joints should also be tested.

FRACTURES OF THE LOWER END OF THE RADIUS.

Colles' Fracture.—This is one of the commonest fractures in the body, and is especially frequent in women beyond middle age.

It is almost invariably the result of a fall on the palm of the hand, the force being received on the ball of the thumb, and transmitted through the carpus to the lower end of the radius. "If at the moment of impact the angle between the axis of the forearm and ground is less than 60°, the line representing the direction of the force passes upwards in front of the axis of the forearm; the whole shock is therefore borne by the lower end of the radius, which is broken off, and the force being continued, the lower fragment is driven backwards" (Chiene).

The fracture takes place through the cancellated extremity of the bone, within a half to three-quarters of an inch of its articular surface. It is usually transverse, but may be slightly oblique. In a considerable proportion of cases it is impacted, and not infrequently the lower fragment is comminuted, the fracture extending into the radio-carpal joint.

When impaction takes place it is usually reciprocal, the dorsal surface of the upper fragment piercing the lower fragment, and the palmar surface of the lower fragment piercing the upper. The mechanism producing comminution of the lower fragment is practically constant, the upper fragment being forced as a wedge into the lower, taking effect first and chiefly on the side of the fragment next the ulna (E. H. Bennett). The periosteum is usually torn and stripped from the palmar aspect of the fragments, while it remains intact on the dorsum.

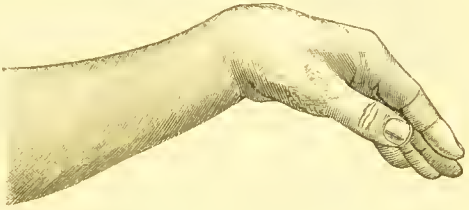

Fig. 123.—Colles' Fracture, in a man æt. 30, from a fall on the palm. "Inverted spoon" deformity well marked.

In the majority of cases the styloid process of the ulna is torn off by traction exerted through the internal lateral ligament.

The resulting *displacement* is of a threefold character: (1) the lower fragment is displaced backwards; (2) its carpal surface is rotated backwards on a transverse diameter of the forearm; while (3) the whole fragment is rotated upward through the arc of a circle, the centre of which is situated at the ulnar attachment of the triangular ligament, the radius of the circle being a line from the ulnar attachment of the triangular ligament to the tip of the styloid process of the radius (Chiene). Stated more simply, the radial styloid is tilted so that it comes to lie at a higher level than normal.

Clinical Features.—In a typical case there is a marked prominence on the back of the wrist, caused by the displaced lower fragment, with a depression just above it (Fig. 123). The natural hollow on the palmar aspect of the radius is filled up by the projection of the upper fragment. The hand and carpus are carried to the radial side by the upward rotation of the lower fragment (Fig. 124), and the radial styloid is raised so that it lies as high, or even higher, than that of the ulna. The lower end of the ulna is rendered unduly prominent by the flexion of the hand to the radial side. The fingers are partially flexed; and the patient supports the injured wrist in the palm of the opposite hand, and avoids all movement of the part.

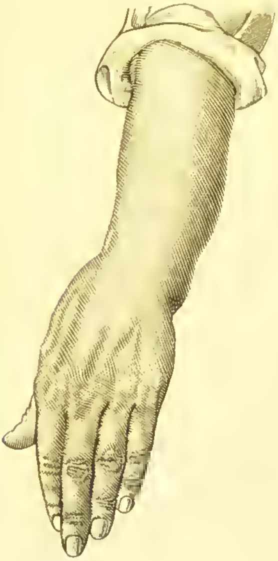

FIG. 124.—Colles' Fracture. From same patient as Fig. 123. Shows radial deviation of hand, and undue prominence of ulnar styloid.

The general outline of the wrist and hand has been compared not inaptly to that of "an inverted spoon." Pronation and supination are lost, the joint is swollen, and there is tenderness on pressure, especially over the line of fracture. Tenderness over the position of the ulnar styloid may indicate fracture of that process, although it is sometimes present without fracture, and has been absent in cases where a fracture was demonstrated by the Röntgen rays (Cathcart). No attempt should be made to elicit crepitus in a suspected case of Colles' fracture, as the manipulations are extremely painful, and are liable to increase the displacement. As a matter of fact it may be wanting in any form of this injury. Its absence, further, is not to be accepted as proving impaction.

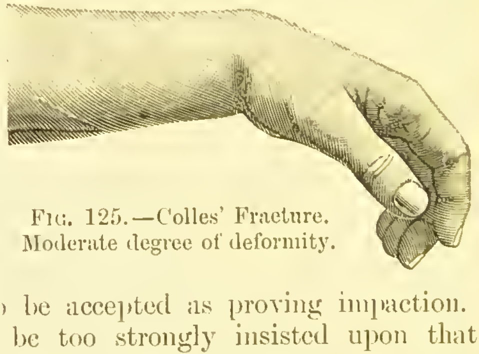

FIG. 125.—Colles' Fracture. Moderate degree of deformity.

Treatment.—It cannot be too strongly insisted upon that success in the treatment of Colles' fracture chiefly depends upon complete and accurate reduction. As considerable force may be necessary, especially when impaction exists, a general anæsthetic is of great assistance. The surgeon grasps the patient's hand, as if shaking hands with him, and resting the palmar surface of the wrist on his bent knee, makes firm traction through the hand, and counter-extension through the forearm, with lateral movements, if necessary, to undo impaction. When the fragments are freed from one another the wrist is flexed, and the hand carried to the ulnar side, while the fragments are moulded into position. When reduction is complete the deformity almost entirely disappears, and the two styloid processes regain their normal positions relative to one another.

As there is no tendency to redisplacement, the simplest possible retentive apparatus should be applied. A firm flannel bandage, a broad strip of adhesive plaster, or a poroplastic wristlet is usually sufficient. In some cases, however, a short dorsal splint to control the wrist-joint; or anterior and posterior splints, similar to those used for fracture of both bones of the forearm, but somewhat narrower, may be employed, as they add to the patient's comfort and sense of security. The hand and forearm are in any case supported in a sling.

To avoid the stiffness which often follows this fracture, the fingers should be freely moved from the first, and massage and movement of the wrist commenced within the first few days, and carried on till movement is perfect. All appliances should be discarded in a fortnight, and the patient encouraged to use the wrist freely.

The various special splints recommended for the treatment of Colles' fracture, such as Carr's, Gordon's, the "pistol splint," and many others, are all designed to correct the deformity as well as to control the fragments. As has already been pointed out, if reduction is complete there is no deformity to correct, while if it is not complete the deformity cannot be corrected by any form of splint.

Unreduced Colles' Fracture.—When union has been allowed to take place without the displacement having been reduced, an unsightly deformity results. In young subjects whose occupation is likely to be interfered with, and in women for æsthetic reasons, the bone may be divided by an osteotome, and set in a straight position. As a rule, however, the usefulness of the limb is not interfered with, and operative measures are rarely called for.

There occasionally occurs a fracture of the lower end of the radius *with forward displacement of the carpal fragment* (*Colles' fracture reversed* or **Smith's fracture**). It is nearly always due to forcible flexion, as from a fall on the back of the hand. Like Colles' fracture, it may be transverse or slightly oblique, impacted, or comminuted. The deformity is characterised by an elevation on the dorsum running obliquely upwards from the ulnar to the radial side of the wrist, and caused by the head of the ulna, which remains in position, and the lower end of the upper fragment. Below this, over the position of the lower radial fragment, is a gradual slope onto the dorsum of the hand. Anteriorly there is a prominence in the flexure of the wrist, and the lower fragment may be felt under the flexor tendons. The hand deviates to the radial side, and thereby still further increases the prominence caused by the lower end of the ulna. The radial styloid is displaced forward, upward, and to the radial side, and the ulnar styloid may be torn off. Crepitus can seldom be elicited.

When the deformity is not well marked, this injury may be mistaken for forward dislocation of the wrist, fracture of both bones low down, or for sprain of the joint.

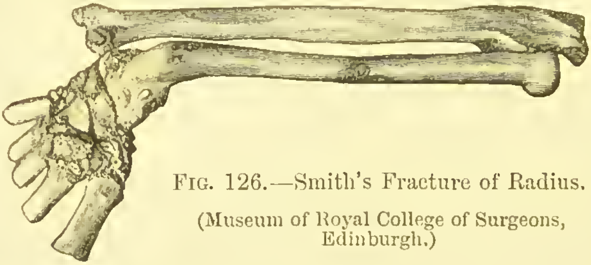

FIG. 126.—Smith's Fracture of Radius.

(Museum of Royal College of Surgeons, Edinburgh.)

The *treatment* is carried out on the same lines as in Colles' fracture.

Longitudinal fractures of the lower end of the radius opening into the joint usually result from the hand being crushed by a heavy weight or in machinery. They are often compound and comminuted.

Separation of the lower epiphysis of the radius is comparatively common between the ages of twelve and eighteen, and is caused by the same forms of violence as produce Colles' fracture. Although the clinical appearances in these two injuries bear a general resemblance to one another, separation of the epiphysis may usually be identified by the directly transverse line of the dorsal and palmar projections, the folding of the skin observed in the palmar depression, the absence of abduction of the hand, and the ease with which muffled crepitus can be elicited (E. H. Bennett). The deformity is readily reduced, and the fragments are easily retained in position.

This injury is often complicated with fracture of the shaft or styloid process of the ulna, or dislocation of the radio-ulnar joint, and it is not infrequently compound. If the growth of the radius is interfered with, it results in a valgus condition of the hand, calling for resection of the lower end of the ulna.

The *treatment* is the same as for Colles' fracture.

Fractures of the Lower End of the Ulna.—The lower end of the *shaft* of the ulna is seldom fractured alone. The *styloid process*, as has already been pointed out, is frequently broken in association with Colles' and other fractures of the lower end of the radius.

Separation of the *lower epiphysis* of the ulna, although a rare injury, is of clinical importance, in view of the fact that, like the radius, nearly the entire growth of this bone takes place at its lower end, and any interference with its epiphysis is liable to arrest its growth, producing a varus condition of the hand and bending of the radius.

The *treatment* is similar to that for Colles' fracture, but the hand is fixed in the position of ulnar flexion.

Simultaneous separation of both epiphyses sometimes occurs, and, as a result of severe violence, may be compound, the lower ends of the diaphyses projecting through a wound on the dorsum.

Fractures of Carpal Bones.—The use of the Röntgen rays has shown that fracture of individual carpal bones is a somewhat commoner injury than has hitherto been supposed. The scaphoid is broken more frequently than any of the others, usually by direct violence or by forced dorsi-flexion, but the clinical features are so obscure, and often so misleading, that an accurate diagnosis without the aid of the X-rays is seldom possible. In the majority of cases the fracture is compound, and associated with other injuries in the region of the wrist.

The *treatment* of simple fractures consists in fixing the wrist and carpal joints by a palmar splint, the metacarpals being slightly hyperextended.

DISLOCATIONS IN THE REGION OF THE WRIST.

The strong ligaments of the articulations about the wrist, the comparatively free movement at the various joints, and the relative weakness of the lower end of the radius whereby it is so frequently fractured, render dislocation a rare form of injury.

Dislocation may occur at the inferior radio-ulnar, the radio carpal, mid-carpal, inter-carpal, or carpo-metacarpal joints.

Dislocation of the **inferior radio-ulnar** articulation is seldom met with, except as a complication of fracture of the lower end of the radius, or in association with sub-luxation of the head of the radius. The head of the ulna usually passes backward, less frequently forward, and but rarely towards the ulnar side.

In children the commonest cause is lifting the child by the hand, and the displacement, as a rule, is only partial.

In adults it may result from forcible efforts at pronation or supination, as in wringing clothes, or from direct violence, the separation being frequently complete and sometimes compound.

The head of the ulna forms a prominence on the dorsal or palmar aspect of the wrist, according to the direction in which it passes, and there is an undue depression on the opposite aspect of the joint. The hand is generally pronated, the rotatory movements at the wrist being restricted and painful, while flexion and extension are comparatively free. When uncomplicated the dislocation is easily recognised, but when complicated with fracture it is apt to be overlooked.

Reduction is readily effected by making direct pressure on the displaced bone and manipulating the joint, especially in the direction of supination.

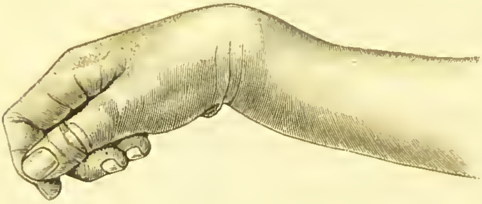

Fig. 127.—Backward Dislocation at Radio-Carpal Articulation, in a man aet. 24, from a fall of 15 feet, landing on back of knuckles.

Dislocations at the **radio-carpal** joint are, in comparison with Colles' fracture, extremely rare. They are often complicated by fractures of the lower ends of the bones of the forearm; are attended by great tearing of the ligaments and displacement of tendons; and are frequently compound. The carpus may be displaced backward or forward, and the separation is usually complete. It is not uncommon for the articular edge of the radius towards which the carpus passes to be chipped off.

Backward dislocation is much the commoner, and results from severe forms of violence, such as a fall from a height on the palm while the hand is dorsi-flexed and abducted. It may also be produced by violent rotation of the wrist.

The clinical appearances closely simulate those of Colles' fracture, or separation of the lower radial epiphysis, but the unnatural projections, both in front and behind, are lower down, and end more abruptly (Fig. 127). The hand is more flexed, and the palm is shortened. The styloid processes retain their normal relations to one another, but that of the radius is nearer to the thumb than it should be, and the carpal bones are found to lie on a plane posterior to the styloids. The radius is not shortened. Unless the swelling is great the articular surfaces may be recognised by palpation.

Dislocation *forward* may result from any form of forced flexion, such as a fall on the back of the hand, or from direct violence. The displaced carpus forms a marked projection on the palmar aspect of the wrist, and there is a corresponding depression on the dorsum. The attitude of the hand and fingers varies, but is usually one of flexion. In other respects it agrees with the dorsal variety.

In both varieties reduction is readily effected by making traction on the hand, and at the same time pushing the carpus into position. A simple splint is worn for about a fortnight, movement and massage being employed from the first.

Dislocation of Carpal Bones.—The two rows of carpal bones may be separated from one another, or any one of the individual bones may be displaced. These injuries result from severe forms of violence, and are very rare. Pain, deformity, and loss of function are the ordinary symptoms. The treatment consists in making direct pressure over the displaced bones, while traction is made on the hand, and the joints freely moved. Of these injuries the most frequently observed is a displacement of the *head of the os magnum* from the scaphoid and semilunar bones. On full flexion of the wrist the loose head of the os magnum forms a prominence on the dorsum of the wrist opposite the base of the third metacarpal, which temporarily disappears on extension or dorsi-flexion. By fixing the hand in this position for a week or ten days the function of the wrist is restored.

The *semilunar* may be displaced forward by forcible dorsi-flexion of the hand, forming a swelling over the inferior radio-ulnar joint, under the flexor tendons. It is usually associated with loss of sensibility in the distribution of the ulnar nerve beyond. The only satisfactory treatment is removal of the bone.

In a few cases the *scaphoid* has been displaced, and subsequently replaced by operation. Separation of any of the other bones is extremely rare.

Carpo-Metacarpal Dislocations.—Any or all of the metacarpal bones may be separated from the carpus by forced movements of flexion or extension. The commonest displacement is backward. The thumb seems to suffer oftener than the other digits. These injuries, however, are so rare, and the deformity is so characteristic, that a detailed description is unnecessary.

There is good reason to believe that the injury commonly described as "incomplete dislocation" or "sub-luxation of the metacarpal of the thumb backward" is really a fracture of the anterior portion of the base of the bone—an injury now known as Bennett's fracture.

Sprain of the wrist is a very common injury resulting from falls on the hand or twisting forms of violence. The marked swelling which rapidly ensues may render it difficult to distinguish this injury from the more severe ones liable to result from similar causes—Colles' fracture, separation of the lower radial epiphysis, and dislocation of the radio-carpal joint.

In a sprain the normal relations of the styloid processes and other bony points about the wrist are unaltered. The most marked swelling is over the line of the articulation on the anterior and posterior aspects of the joint. There is no radial deviation of the hand, as in Colles' fracture. There is usually some effusion into the sheaths of the tendons passing over the joint, and in moving the fingers a peculiar creaking, which may simulate crepitus, can be elicited in some cases. There is marked tenderness on making pressure over the line of the joint, as well as over one or other of the lateral ligaments, depending upon which has been overstretched or torn. Passive movements which tend to put the damaged ligaments on the stretch also cause pain. It has to be borne in mind, however, that in many cases of Colles' fracture there is extreme tenderness on pressing over the ulnar styloid and external lateral ligament, as these structures are frequently injured as well as the radius, but the point of maximum pain and tenderness is over the seat of fracture of the radius.

The *treatment* consists in the early employment of massage and movement supplemented by douches.

INJURIES OF THE FINGERS.

Fractures.—*Fractures of the metacarpals* of the four inner fingers are comparatively common. When they result from direct violence, such as a crush between two heavy objects, they are often multiple and compound. Indirect violence, acting in the long axis of the bone and increasing its natural curve, such as a fall or a blow on the knuckle, as in striking with the closed fist, usually produces a simple fracture about the middle of the shaft, the proximal end of the distal fragment projecting towards the dorsum of the hand. Apart from this there is little deformity, as the adjacent metacarpals act as natural splints and tend to retain the fragments in apposition. A sudden sharp pain may be elicited at the seat of fracture on making pressure in the long axis of the finger; and unnatural mobility and crepitus may usually be detected by manipulation of the fragments. These fractures are readily recognised by the X-rays. Firm union usually results in three or four weeks.

Treatment.—When the fracture is transverse, and especially when it implicates the middle or ring fingers, the most convenient method of treatment is to make the patient grasp a firm pad, such as a roller bandage covered with a layer of wool, and fix the closed fist by a figure-of-eight bandage (Fig. 128). In this way the adjoining metacarpals are utilised as lateral splints. To prevent the extensor tendon forming attachments to the broken bone, active and passive movements must be carried out daily, and the bandage may be removed at the end of a fortnight.

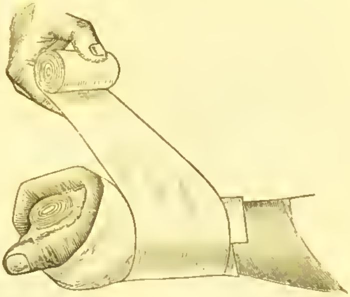

FIG. 128.—Treatment of Fracture of Metacarpals by Pad in the Palm and "Closed-fist" Bandage.

In oblique fractures with a tendency to overriding of the fragments, especially in the case of the index and little fingers, it is sometimes necessary to apply extension to the distal segment of the digit, by means of adhesive plaster, to which elastic tubing is attached and fixed to the end of a rectangular splint reaching well beyond the finger tips (Fig. 129) (Chiene). This should be worn for three weeks, passive movement being carried out after the first week.

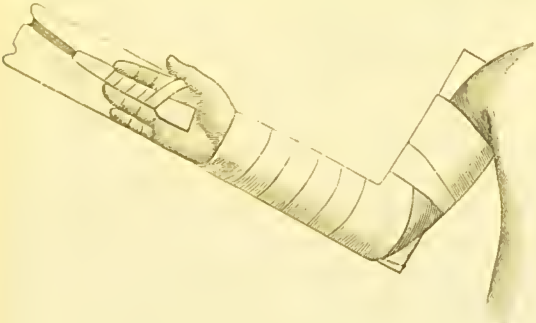

FIG. 129.—Extension applied for Oblique Fracture of Metacarpal.

Bennett's Fracture of the Base of the first Metacarpal Bone.—Bennett of Dublin has described an injury of the thumb, which, although comparatively common, is often mistaken for a sub-luxation backward of the carpo-metacarpal joint, or a simple "stave of the thumb." It consists in an "oblique fracture through the base of the bone, detaching the greater part of the articular facet with that piece of the bone supporting it which projects into the palm" (Fig. 130).

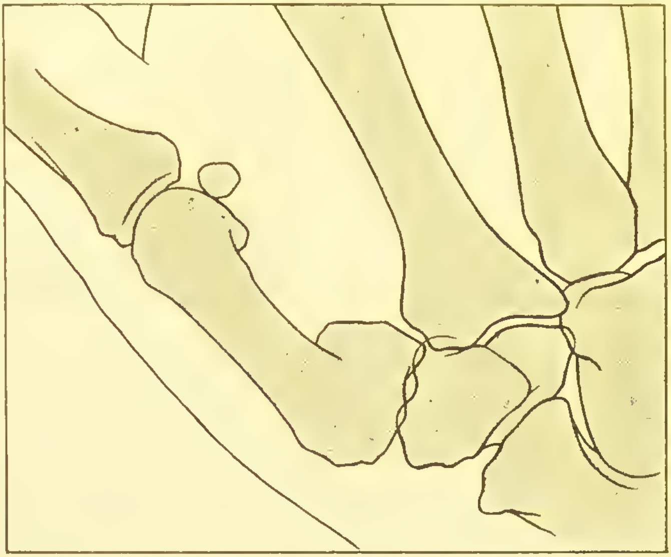

FIG. 130.—Tracing of Radiogram showing Bennett's Fracture of Base of Metacarpal of Thumb.

(Mr. J. W. Struthers' case.)

It results from severe force applied directly to the point of the thumb, driving the metacarpal against the trapezium, and chipping off the palmar part of the articular surface. The rest of the metacarpal slips backward, forming a slight prominence on the dorsal aspect of the joint. The pain and swelling in the region of the fracture often prevent crepitus being elicited, and as the deformity is not at once evident the nature of the injury is liable to be overlooked. The fracture is readily recognised by the use of the X-rays. It may occur in either hand, but on account of the greater exposure of the right hand to injury it is commoner on that side. The importance of making a correct diagnosis lies in the fact that unless properly treated this injury frequently results in prolonged impairment

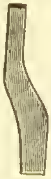

FIG. 131.—Splint for Fracture of Base of Metacarpal of Thumb.

of function, full abduction and fine movements requiring close opposition of the thumb being specially interfered with.

The *treatment* consists in careful reduction of the fracture by extension, and the application of an accurately fitting pad over the extremity of the displaced bone, maintained in position by a light angular splint (Fig. 131). This splint is first fixed to the extended and abducted thumb, and while extension is made by pushing it downwards the upper end is fixed to the wrist (Fig. 132A). The apparatus is worn for four weeks, being carefully readjusted from time to time to maintain the extension. A moulded poroplastic splint applied on the same principle may be employed (Fig. 132B). Massage and movement should be commenced within a few days of the injury.

Fractures of phalanges usually result from direct violence, and on account of the superficial position of the bones are often compound, and are attended with much bruising of soft parts. Force applied to the distal end of the finger also may fracture a phalanx. The proximal phalanges are broken oftener than the others. The deformity is usually angular, with the apex towards the palm, and if union takes place in this position, flexion and grasping are interfered with. Unnatural mobility and crepitus can usually be recognised, but, on account of the swelling and tenderness, diagnosis is sometimes very difficult. Firm union takes place in two or three weeks. In oblique and comminuted fractures union may take place with overlapping, producing a deformity which is sometimes troublesome by preventing the wearing of a glove or of rings. In compound fractures non-union sometimes occurs and causes persistent disability. In doubtful cases radioscopy renders valuable aid, as the parts are readily seen by the screen.

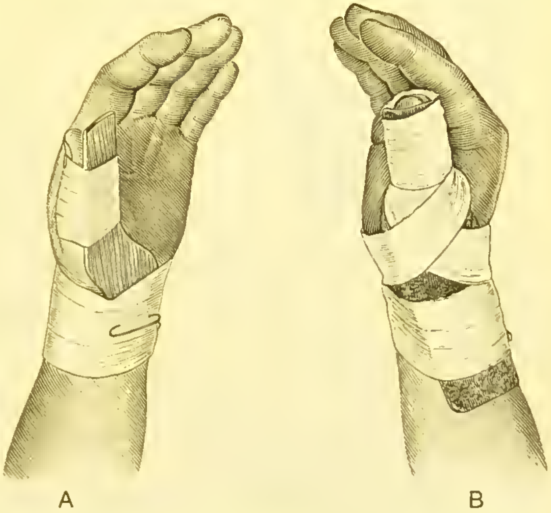

FIG. 132.—*A*. Splint applied as used by Bennett. *B*. Poroplastic Moulded Splint for Bennett's Fracture.

Treatment.—The contiguous fingers should be utilised as lateral splints, while a long palmar splint projecting beyond the fingers is employed to control the wrist-joint. Early movement and massage are necessary to prevent adhesions of tendons and consequent stiffness. In oblique and comminuted fractures it may be necessary to anæsthetise the patient to effect reduction; and in some cases extension applied in the same way as for fracture of a metacarpal is useful. When it is particularly desirable to avoid deformity an open operation may be advisable.

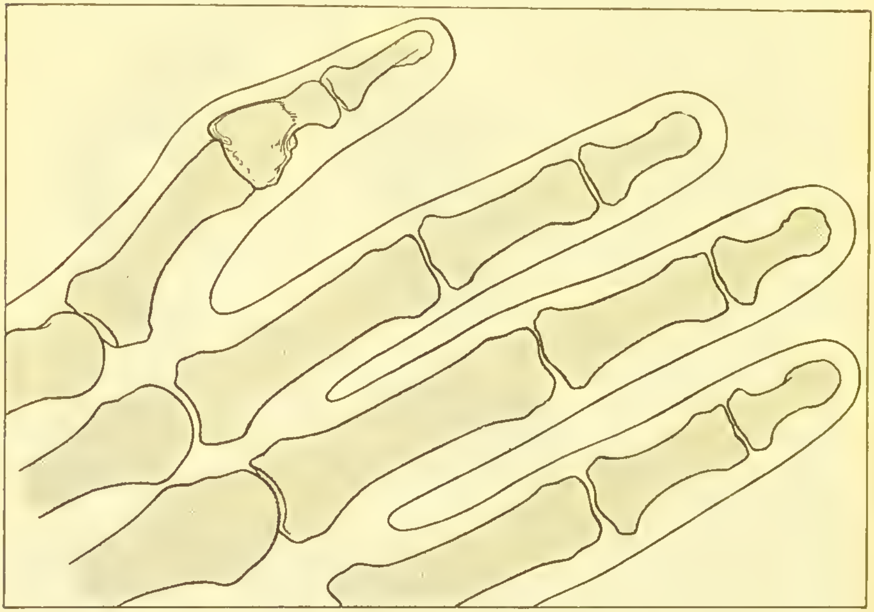

FIG. 133.—Tracing of Radiogram of Fracture of Phalanx united.

Dislocations.—*Dislocations of the metacarpo-phalangeal joint of the thumb.*—The commonest dislocation at this joint is a *backward* displacement of the proximal phalanx, which may be complete or incomplete. Its special clinical importance lies in the fact that much difficulty is often experienced in effecting reduction.

This dislocation is usually produced by extreme dorsi-flexion of the thumb, whereby the palmar or glenoid, and the lateral ligaments are torn from their metacarpal attachments, the phalanx carrying with it the glenoid ligament and sesamoid bones. The head of the metacarpal bone passes between the two heads of the flexor brevis pollicis, and the tendon of the long flexor slips to the ulnar side. The phalanx passes on to the dorsum of the metacarpal, where it is held erect by the tension of the abductor and adductor muscles.

The attitude of the thumb is characteristic (Fig. 134). The metacarpal is adducted, its head forming a marked prominence on the front of the thenar eminence, and the phalanges are displaced backwards and more or less flexed upon one another.

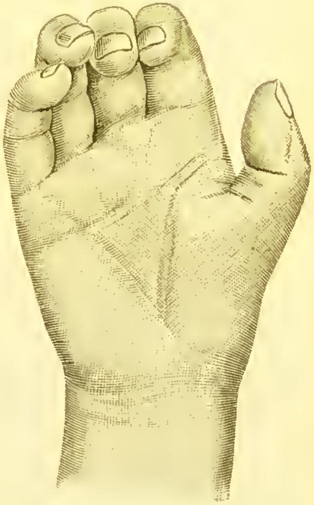
FIG. 134.—Backward Dislocation of Metacarpo-Phalangeal Joint of Thumb.

Many explanations of the difficulty so often experienced in reducing this variety of dislocation have been offered, but the consensus of opinion now seems to be that it is due to the interposition of the glenoid ligament and the sesamoid bones between the phalanx and the metacarpal, and that this is most frequently the result of ill-advised efforts at reduction. In some cases the tension of the long flexor tendon may be a factor, but the "button-holing" by the short flexor is probably of no importance.

Reduction is to be effected by flexing and adducting the metacarpal while the phalanx is hyperextended and pushed down towards the joint and levered over the head of the metacarpal.

When this manipulation fails, the glenoid ligament should be divided longitudinally through a puncture made with a tenotomy knife on the dorsal aspect of the joint, so as to separate the sesamoid bones and permit the passage of the head between them. An open operation is seldom necessary.

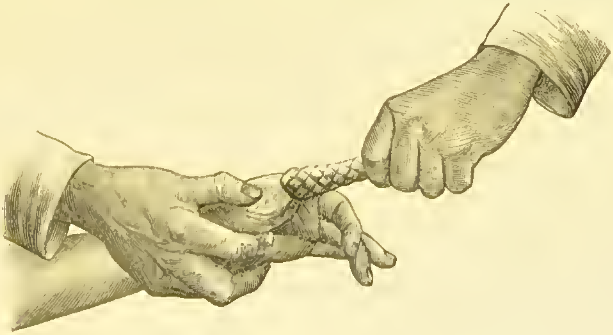
FIG. 135.—Reduction of Dislocation of Thumb with aid of "Indian Puzzle."

Dislocation *forward* at [this joint is rare. It results from forced flexion of the thumb with abduction, tearing the posterior and internal lateral ligaments. The deformity is characteristic: the rounded head of the metacarpal projecting behind the level of the joint, while the base of the phalanx forms a prominence among the muscles of the thenar eminence. The phalanges may be rotated outward or inward.

Reduction is easily effected by making traction on the phalanges and carrying out movements of flexion and extension. The deformity, however, is very liable to be reproduced unless a retentive apparatus is securely applied.

Lateral dislocations of the thumb are very rare.

Dislocation of the *metacarpo-phalangeal joint of the fingers* may be backward or forward. They are less common than those of the thumb, but present the same general characters. In the backward variety the same difficulty in reduction as is met with in the corresponding dislocation of the thumb sometimes occurs, and is to be dealt with on the same principles.

Inter-phalangeal Dislocations.—The middle and the ungual phalanges may be displaced backwards, forwards, or laterally. The clinical features are characteristic, and the diagnosis, as well as reduction, is easy. These dislocations are very frequently compound.

Persistent flexion of the terminal phalanx of the thumb or fingers (drop or mallet finger) may result from violence applied to the end of the digit when in the extended position—as, for example, in attempting to catch a cricket ball. The terminal phalanx is flexed towards the palm, and the patient is unable to extend it voluntarily, although there is no difficulty in carrying out passive movements at the joint. This condition is of the nature of a sprain, and is usually ascribed to stretching or tearing of the insertion of the tendon of the long extensor. The treatment consists in applying a short splint secured by a few turns of adhesive plaster to control the affected joint.

Massage and movement should be employed daily after the first week. Tubby has successfully shortened the stretched tendinous expansion by an open operation.

CHAPTER XXV.

INJURIES IN THE REGION OF THE PELVIS, HIP-JOINT, AND THIGH.

FRACTURES OF PELVIS: *Varieties*—INJURIES IN REGION OF HIP: Surgical anatomy; *Fracture of head of femur; Fractures of neck of femur; Fracture below lesser trochanter*—DISLOCATIONS OF HIP: *Varieties*—Sprains—Contusions—FRACTURES OF SHAFT OF FEMUR.

FRACTURE OF THE PELVIS.

FOR descriptive as well as for practical purposes it is useful to divide fractures of the pelvis into those which implicate the pelvic girdle as a whole, and those confined to individual bones.

In all, the prognosis depends upon the severity of the visceral lesions which so frequently complicate these injuries, rather than upon the fractures themselves.

Fractures implicating the pelvic girdle as a whole usually result from severe crushing forms of violence, such as the fall of a mass of coal or a pile of timber, or the passage of a heavy wheel over the pelvis. The force may act in the transverse diameter of the pelvis, or in its antero-posterior diameter. The pelvic viscera may be lacerated by the tearing asunder of the bones, or perforated by sharp fragments.

As a rule, more than one part of the pelvis is broken, the situation of the lesions and the clinical features varying in different cases.

Separation of the pubic symphysis may result from external violence, from forcible abduction of the thighs, or it may happen during child-birth. In some cases there is no permanent displacement, the only evidence of the injury being localised pain in the region of the symphysis on making pressure over any part of the pelvis. In others the two pubic bones overlap one another, in which case the membranous portion of the urethra, or the bladder wall, is very liable to be torn. The displaced bones may be palpated through the skin, or by vaginal or rectal examination.

The *pubic portion* of the pelvic ring is the most common seat of fracture. The bone gives way at its weakest points—namely, through the horizontal ramus of the pubes just in front of the pectineal eminence, and at the lower part of the descending ramus (Fig. 136). The intervening fragment of bone is isolated, and may be displaced. These fractures are frequently bilateral, and are often associated with separation of the opposite sacro-iliac joint, with longitudinal fracture of the sacrum (Fig. 138), or with other fractures of the pelvic bones.

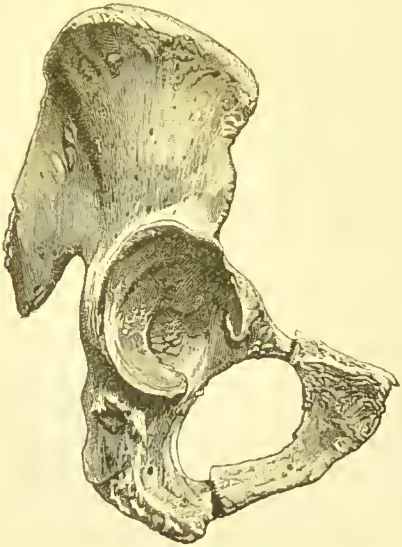

FIG. 136.—Fracture of Pelvis through Horizontal and Descending Rami of Pubes.

Injuries of the membranous urethra and bladder are frequent accompaniments of these fractures. Blood may escape from the meatus, pure or mixed with urine; or blood and urine may be extravasated into the cellular tissue of the pelvis or perineum. Less commonly the rectum, vagina, or iliac blood-vessels are damaged.

Localised tenderness at the seat of fracture, and pain referred to that point on pressing together or separating the iliac crests, and mobility of the fragments with crepitus, are usually present. The fragments may sometimes be felt on rectal or vaginal examination. As in all cases of pelvic fracture, shock is a prominent feature.

The lateral and posterior aspects of the pelvic ring may be implicated either in association with pubic fractures or independently. Thus a fracture of the iliac bone may run into the great sciatic notch; or a vertical fracture of the sacrum or separation of the sacro-iliac joint may break the continuity of the pelvic brim. In rare cases these injuries are accompanied by damage to the intestines, the rectum, the sacral nerves, or the iliac blood-vessels.

Treatment.—In all fractures of the pelvis it is of importance that the patient be moved and handled with the greatest possible care, lest fragments become displaced and injure the viscera.

He should be put to bed on a firm mattress. Some surgeons prefer a mattress made in three pieces, for convenience in using the bed-pan and for the prevention of bed-sores, but we have never found this to be of any service in practice.

Before the treatment of the fracture is commenced the surgeon must satisfy himself, by the use of the catheter and by other means, that the urethra and bladder are intact. Should these or any other of the pelvic viscera be damaged, these injuries must receive the first attention.

The treatment of the fracture itself consists in adjusting the fragments, as far as possible by manipulation, applying a firm binder or many-tailed bandage round the pelvis, and fixing the knees together by a bandage.

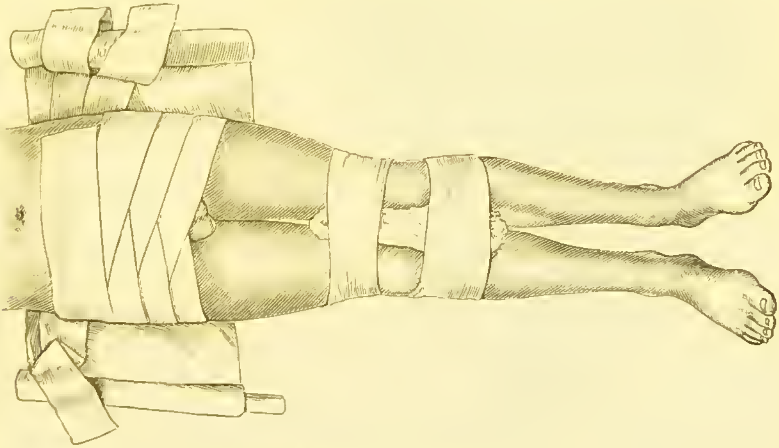

FIG. 137.—Many-tailed Bandage and Binder for Fracture of Pelvis.

In some cases extension may be applied to both legs, with the limbs abducted and fixed by sand-bags.

Compound fractures being commonly associated with extravasation of urine are liable to septic complications. Loose fragments should be removed, as they are very prone to undergo necrosis.

The patient is confined to bed for six or eight weeks, and it may be several weeks more before he is able to resume active employment.

The pelvic girdle may be fractured by force transmitted through the femur, from a fall on the feet, the knees, or the great trochanter. The *acetabulum* may merely be fissured, or the head of the femur may be forcibly driven through its floor into the pelvic cavity, either by fracturing the bone, or, in young subjects, by bursting asunder the epiphysial junction of the constituent bones. When the femoral head penetrates into the pelvis the condition simulates a fracture of the neck of the femur, but the trochanteric region is more depressed, and the displaced head may be recognised on rectal or vaginal examination. The limb is shortened, the movements of the joint much restricted and painful, but crepitus is not always to be detected.

When the head penetrates the acetabulum, reduction should be attempted by traction and manipulation. After reduction the limb is fixed in a long splint with extension as for fracture of the neck of the femur. Reduction is often very difficult, and sometimes impossible.

Fractures of Individual Bones of the Pelvis.—*Ilium.*—The expanded portion of the iliac bone is often broken by direct violence, the detached fragments varying greatly in size and position. In young persons the *anterior superior spine* has been torn off and displaced downwards by powerful contraction of the sartorius muscle; and the *anterior inferior spine* by strong traction on the λ-shaped ligament.

The whole or part of the *crest* may be separated by similar forms of violence.

When the fracture implicates the *ala* of the bone it usually starts at the triangular prominence near the middle of the crest, and runs backwards or forwards, passing for a variable distance into the iliac fossa. The displaced fragment may sometimes be palpated and made to move when the muscles attached to it are relaxed by bending the body forward and towards the affected side and flexing the thighs. Pain and crepitus may be elicited at the same time.

These fractures are treated by applying a firm binder, and by placing the patient in such a position as will relax the muscles attached to the displaced fragment—in the case of the iliac spines by flexing the thigh upon the pelvis, and in the case of the crest or ala by raising the shoulders. Union takes place in three or four weeks.

Fracture of the *ischium* alone is very rare. It results from a fall on the buttocks, the entire bone or only the tuberosity being broken. There is little or no displacement, and the diagnosis is made by external manipulation and examination through the rectum or vagina.

In addition to the fracture of the floor of the *acetabulum* already referred to, it is necessary to mention a fracture of the upper and back part of the rim of that cavity which may accompany dorsal dislocation of the hip. Its clinical importance lies in the fact that crepitus may be present in addition to the symptoms of dislocation, and that the displacement is easily reproduced after reduction. This injury is liable to be mistaken for a fracture of the neck of the femur, but the flexion and internal rotation of the hip should prevent error. The treatment is the same as for fracture of the neck of the femur.

A longitudinal fracture of the *sacrum* may occur and implicate the posterior part of the pelvic ring, as has already been mentioned. In rare cases the lower half of the bone is broken *transversely* from a fall or blow, and the lower part is bent forward so that it projects into the pelvis and may press upon or tear the rectum. The sacral nerves also may be damaged causing partial paralysis of the lower limbs, bladder, or rectum. These fractures are frequently comminuted and compound, and the soft parts may be so severely bruised and lacerated that sloughing follows. On rectal examination the lower segment of the bone may be felt, and on manipulating it pain and crepitus may be elicited.

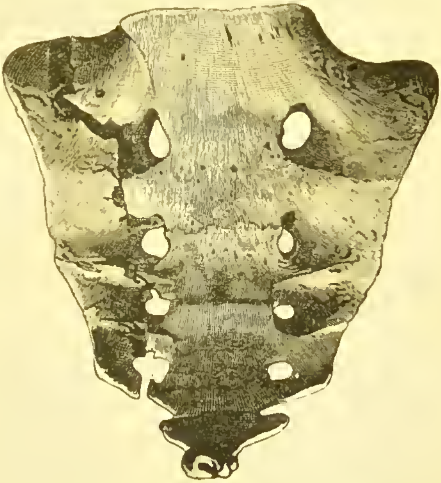

Fig. 138.—Longitudinal Fracture of Sacrum from same Patient as Fig. 136.

Fracture of the *coccyx* is due to a direct blow, or it may occur during parturition. As a result of this injury the patient may have severe pain on sitting or walking—*coccygodynia*. The loose fragment can usually be recognised by rectal examination. An attempt should be made to replace the lower fragment. The patient is kept in bed with a firm binder applied. If the lower fragment is united at an angle so as to cause pressure on the rectum, it may be necessary to excise it.

Injuries in the Region of the Hip.

We have here to consider the various fractures of the upper end of the femur; dislocations and sprains of the hip-joint; and contusions of the hip.

Surgical Anatomy.—The strength of the hip-joint depends primarily on its osseous elements—the rounded head of the femur filling the deep socket of the acetabulum, to the bottom of which it is attached through the medium of the ligamentum teres. The edge of the acetabulum is specially strong above and behind, while there is a gap in its lower margin, bridged over by the cotyloid ligament.

In relation to fractures of the upper end of the femur it is to be borne in mind that the antero-posterior diameter of the neck is less than that of the shaft, and that as a considerable portion of the great trochanter lies behind the junction of the neck with the shaft, this prominence takes little or no part in bearing any strain put upon the upper end of the bone. The head and neck of the femur are nourished by the thick, vascular periosteum, and through certain strong fibrous bands reflected from the attachment of the capsule—the cervical ligaments of Stanley. These ligaments play an important part in determining union in fractures of the neck of the femur. It is commonly alleged that an alteration in the angle of the femoral neck takes place with advancing years. Whether this be true or not, it is now generally recognised that it is of no importance in relation to fractures in this region.

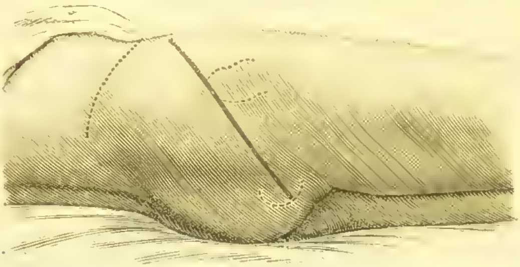

FIG. 139.—Nélaton's Line.

The capsular ligament of the hip is of exceptional strength. It is attached above to the entire circumference of the acetabulum, and below to the neck of the femur in such a way that while the whole of the anterior and inferior aspects of the neck lie within its attachment, only the inner half of the posterior and superior aspects is intracapsular. The capsule is augmented by several accessory bands, the most important of which is the *ilio-femoral* or *Λ-shaped ligament* of Bigelow, which passes from the anterior inferior iliac spine to the anterior inter-trochanteric line, its fasciculi being specially thick towards the upper and lower ends of this ridge. The inner limb of this ligament limits extension of the thigh, while the outer limits eversion and adduction. The weakest part of the capsular ligament lies opposite the lower and back part of the joint.

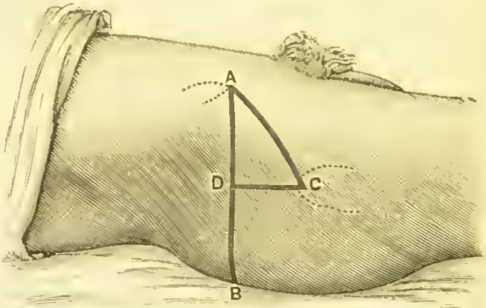

FIG. 140.—Bryant's Lines.

The hip-joint is surrounded by muscles which contribute to its strength, the most important from the surgical point of view being the obturator internus, which plays an important part in certain dislocations, and the ilio-psoas, which influences the deformity in various lesions in this region.

Except in very thin subjects the constituent elements of the hip-joint cannot be palpated through the skin. A line drawn vertically downwards from the middle of Poupart's ligament passes over the centre of the joint, which, in adults, lies on the same level as the tip of the great trochanter. In children it is somewhat higher.

For purposes of clinical diagnosis it is necessary to locate certain bony prominences, the most important of which are:—(1) The *anterior superior iliac spine*, which is most readily recognised by running the fingers along Poupart's ligament from within outwards. (2) The *ischial tuberosity*, which in the extended position of the limb is overlapped by the lower margin of the gluteus maximus muscle, and is therefore not easily located with precision. By pressing from below upwards in the gluteal fold the smooth, rounded prominence can usually be detected. (3) The quadrilateral *great trochanter* is readily recognised on the outer aspect of the hip. Its highest point or *tip* can best be felt by pressing over the gluteal muscles from above downwards.

Clinical Tests.—If a line be drawn from the anterior superior iliac spine to the most prominent part of the ischial tuberosity, it just touches the tip of the great trochanter. This is known as *Nélaton's line* (Fig. 139).

Bryant's test is applied with the patient lying on his back, and consists in dropping a perpendicular AB from the anterior superior iliac spine, and drawing a line CD from the tip of the great trochanter to intersect the perpendicular at right angles. This is done on both sides of the body, and the length of the lines CD compared. Shortening on one side indicates an upward displacement of the trochanter, lengthening its downward displacement. The third side AC of the triangle indicates the distance between the anterior spine and the tip of the trochanter.

Chiene's test, which is simpler than either of these, consists in applying a strip of lead or tape across the front of the body at the level of the anterior superior iliac spines, and another touching the tips of the two trochanters. Any want of parallelism in these lines indicates a change in the position of one or other trochanter.

FRACTURES OF THE UPPER END OF THE FEMUR.

It will be convenient here to study the various fractures of the femur in the vicinity of the hip which are liable to be confused in diagnosis with one another and with dislocations. These include fractures of the head, the neck, the trochanters, and the shaft just below the trochanters.

Fracture of the **head of the femur** is exceedingly rare. It is usually a complication of backward dislocation of the hip. There is splitting of the articular surface by impact against the edge of the acetabulum, analogous to the indentation fracture of the head of the humerus, which may accompany dislocation of the shoulder.

In a few cases the *upper epiphysis* has been separated.

FRACTURES OF THE NECK.

It has long been customary to divide fractures of the neck of the femur into two groups—"intra-" and "extra-capsular"; but inasmuch as in a considerable proportion of cases the line of fracture falls partly within and partly without the capsule, this classification is wanting in accuracy. It is more correct to divide these fractures into (1) those occurring *through the narrow part of the neck*, which are nearly always purely intracapsular; and (2) those occurring *through the base of the neck*, in which the line of fracture lies inside the capsule in front, but outside of it behind.

It is of considerable clinical importance to distinguish between fractures in these two positions. The first group occurs almost exclusively in old persons from slight forms of indirect violence, and is very liable, on account of the feeble vascular supply to the upper fragment, to be followed by absorption of the neck, which delays or may even entirely prevent union. The second group usually occurs in robust adults, and results from severe forms of violence applied directly to the trochanter. In this group firm osseous union usually takes place.

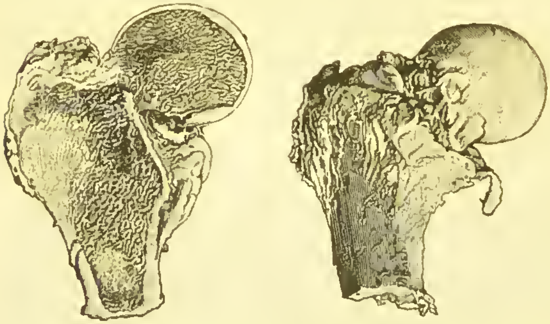

FIG. 141.—Fracture through Narrow Part of Neck of Femur. On surface view and on section. The neck of the bone has undergone absorption.

Fracture of the Narrow Part of the Neck or Intracapsular Fracture.—It was formerly believed that this fracture was exceedingly rare *in children*, but by the use of the X-rays and from the study of the condition known as coxa vara, it has been shown that it occurs with considerable frequency. In children the fracture is of the greenstick variety, and the patient is often able to use the limb within a few days of the injury.

This injury, however, is most frequently met with in elderly persons, especially in women, and is usually produced by comparatively slight forms of indirect violence—such, for example, as result from the foot catching on the edge of a carpet, a stumble in walking, or missing a step in going down stairs.

The line of fracture, which is usually transverse but may be oblique or irregular, lies, as a rule, entirely within the capsule. The outer fragment, which includes the base of the neck, the trochanters, and the shaft, is usually displaced upward and rotated outward. Not infrequently the periosteum remains intact at some point, and the cervical ligaments are untorn—a condition which tends to prevent displacement and to favour union.

Impaction is less common than in fracture through the base of the neck, and it usually results from the patient falling on the outer aspect of the trochanter, the outer fragment penetrating the inner. The posterior part of the neck is more comminuted than the anterior. All the symptoms of fracture are obscured, and it is often very difficult at first to diagnose the condition from a bruise. In old people such impaction should not be undone, as it favours union

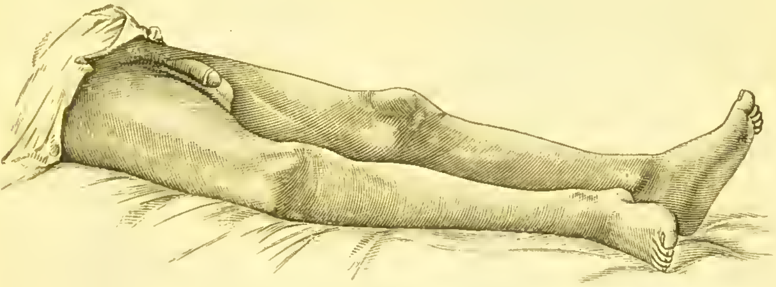

Fig. 142.—Fracture of Neck of Right Femur, showing shortening, abduction, eversion, and flexion of limb.

Clinical Features.—The violence being as a rule indirect, there is at first little or no discoloration in the vicinity of the fracture, but it may appear a few days later. The limb is generally at once rendered useless, and the patient lies helpless, although in some cases, especially in impacted fractures, he may have been able to walk some distance after the accident.

There is great pain and tenderness in the region of the hip on making the slightest movement ; and a specially tender spot may sometimes be localised, indicating the seat of fracture.

On placing the pelvis as square as possible, and comparing the measurements of the limbs from the anterior superior spine to the external malleolus, shortening of the injured limb to the extent of from one to three inches may be found. On applying Nélaton's, Bryant's, or Chiene's tests, the tip of the great trochanter will be found elevated. It is also further back and less prominent than normal. Very often the shortening in intra-capsular fracture does not become apparent till a day or two after the accident. In impacted fracture it may be very slight.

The whole limb is usually everted to a greater or less degree, and is slightly abducted. The ilio-tibial band of the fascia lata is relaxed.

The symptoms are so variable, and often so slight, that it may be exceedingly difficult, if not impossible, to make a positive diagnosis immediately after the accident. In all cases of uncertainty the patient should be put to bed, and treated as for a fracture. In the course of a few days, when the swelling has subsided and the pain abated, a further examination may be made, and the subsequent treatment determined by the result.

Crepitus is not a constant sign, and should not be diligently sought for, as the necessary manipulations are liable to disengage the fragments and to increase the deformity. For the same reason rotatory movements are to be avoided. It is often stated that when the neck of the femur is broken the trochanter may be recognised to rotate through the arc of a smaller circle than under normal conditions. Theoretically this may be true, but the difference is so slight as to render the sign of little clinical value.

In examining an old person who has sustained an injury in the region of the hip, it should be borne in mind that the limb may be shortened and everted as a result of arthritis deformans, and that the appearances may suggest the presence of a fracture. Under these conditions, however, the ilio-tibial band of the fascia lata is not relaxed as it is in the case of a fracture attended with shortening and eversion.

Prognosis.—A fracture of the neck of the femur in an old person is always attended with considerable risk to life, a large proportion of the patients dying within a few weeks or months of the accident from causes directly associated with it. In some cases the mental and physical shock so far diminishes the vitality of the patient that death ensues within a few days. It is possible that fat embolism may account for death in some of the rapidly fatal cases. In others the continued dorsal position induces hypostatic congestion of the lungs which proves fatal; or, owing to the difficulties of nursing, bed-sores may form, and death result from septic absorption. Frequently the prolonged confinement to bed, the continuous pain, and the natural impairment of appetite wear out the patient's strength. In many cases the patient becomes peevish, irritable, or mentally weak.

Osseous union is the exception in intra-capsular fracture, especially when the periosteum and cervical ligaments have been completely torn. In sub-periosteal and in impacted fractures it sometimes occurs. As a rule, however, the neck of the femur becomes absorbed and disappears, the head of the bone comes to lie in contact with the base of the trochanter, and a false joint forms. In a few cases chronic changes of the nature of arthritis deformans occur in and around such false joints. There is reason to doubt the statement that absorption of the neck follows a simple contusion of the bone without fracture.

Fracture through the Base of the Neck.—This fracture is usually produced by severe violence inflicted directly over the great trochanter, although it is occasionally due to falls on the feet or knees. It has been attributed to muscular action alone. In these latter cases traction on the ligaments is probably an important factor.

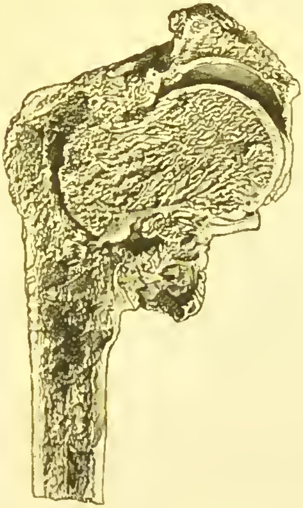

FIG. 143.—Fracture through Base of Neck of Femur with Impaction into the Trochanters.

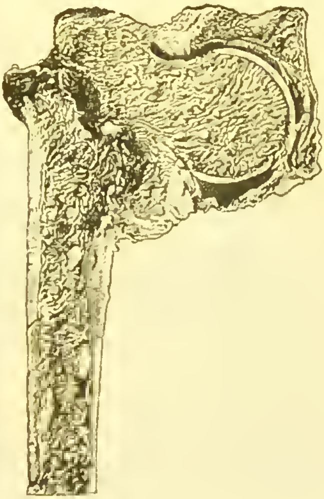

FIG. 144.—Non-Impacted Fracture through Base of Neck of Femur with splitting of Trochanters.

Although often spoken of as "extra-capsular," the line of fracture is generally partly within and partly without the capsule, on account of the disposition of the capsular ligament already described. It usually lies close to the junction of the neck with the shaft. In the great majority of cases this fracture of the neck is accompanied by breaking of one or both trochanters. This is due to the inner fragment being driven as a wedge into the outer, splitting up the trochanters. When the fragments remain interlocked, the fracture is of the *impacted* variety; otherwise it is spoken of as *non-impacted.*

Clinical Features.—Although this fracture is most commonly met with in strong adults, it may also occur in the aged.

The outer aspect of the hip shows marks of bruising, and there is always severe pain and a considerable degree of shock. There is generally marked eversion of the limb, with shortening, which, in most cases, is evident immediately after the accident, and is due to the lower fragment being drawn up by the muscles inserted into the great trochanter and upper end of the shaft. In some cases the shortening does not appear for some time after the injury.

On applying the various tests the great trochanter is found displaced upwards, and there is a marked antero-posterior broadening of the trochanteric region of the hip, especially in the impacted form of fracture, and the ilio-tibial band is relaxed. On pressing the fingers into the outer part of Scarpa's triangle, a bony mass consisting of the broken fragments may be felt, and is tender on pressure.

In non-impacted cases unnatural mobility with crepitus may be elicited. Impaction, by masking the symptoms, adds materially to the difficulty of diagnosis.

Prognosis.—The risks to life in the aged are similar to those of intra-capsular fracture. In youths and healthy adults the chief danger lies in shortening of the limb, resulting in impaired usefulness. In children it may give rise to coxa vara.

Bony union is the rule, as the vascularity of the fragments is but little interfered with. There is always, however, considerable thickening due to displaced fragments and callus in the region of the trochanter, and in unsuccessfully treated cases there is a varying degree of shortening and eversion of the limb. In cases where the outer fragment lies in front of the inner there is permanent inversion.

Fracture of the *great trochanter* may occur from direct violence. When fractured alone, the trochanter is displaced by the gluteal muscles, causing broadening of the outer aspect of the hip. In young persons the epiphysis of the great trochanter may be separated, but this is very rare. These injuries are treated on the same lines as fractures of the neck.

Treatment.—In treating a fracture of the neck of the femur it is necessary to consider the age and general condition of the patient; whether the fracture is impacted or not; and the site of the fracture—whether in the narrow part of the neck or at its base. "The first indication is to save life, the second to get union, and the third to correct or diminish displacements" (Stimson).

In old and debilitated patients prolonged confinement to bed in the dorsal attitude is liable to endanger life by favouring hypostatic congestion of the lungs and the formation of bed-sores. As bony or even firm fibrous union seldom takes place in these patients, especially when the fracture is through the narrow part of the neck, it is generally advisable to get them out of bed as speedily as possible. For the first few days the patient may be kept on his back, the limb being steadied by sand-bags; but on the first sign of respiratory or cardiac trouble he should be propped up in bed, and as soon as possible lifted into a chair. The leg may be fixed in a Thomas' hip splint, a leather case, or by a plaster-of-Paris spica applied to the hip, while he gets about on crutches or in a bath-chair. In all such cases care should be taken to avoid undoing impaction.

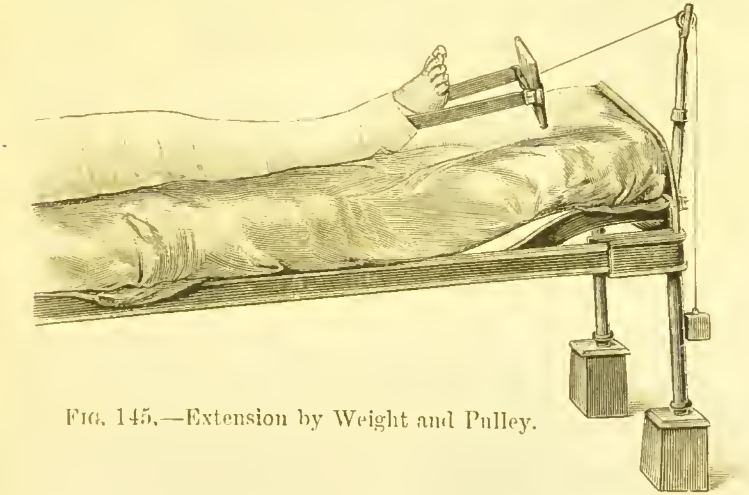

FIG. 145.—Extension by Weight and Pulley.

In robust patients, on the other hand, there is no danger from prolonged immobilisation in bed, and as union without deformity can be attained in no other way this is always advisable. When the shortening and eversion are excessive they should be completely corrected under anæsthesia before the retentive apparatus is applied, any impaction which exists being undone. When the deformity resulting from impaction is slight, however, it is best to leave it, as it facilitates speedy and firm union.

Shortening[1] is best counteracted by *extension with weight and pulley.* Strips of strong adhesive plaster are applied to each side of the limb, reaching well above the middle of the thigh. To the lower ends of these are attached broad tapes, to which a stirrup is buckled, and through it traction is made by means of a cord passing over a pulley, the weight varying with the requirements of the case. In a moderately muscular adult a weight of from six to eight pounds should be applied at first, and increased or diminished as required. The correct weight to employ is that which maintains the length of the limb at its normal. In some cases it may be necessary to use as much as fifteen or twenty pounds.

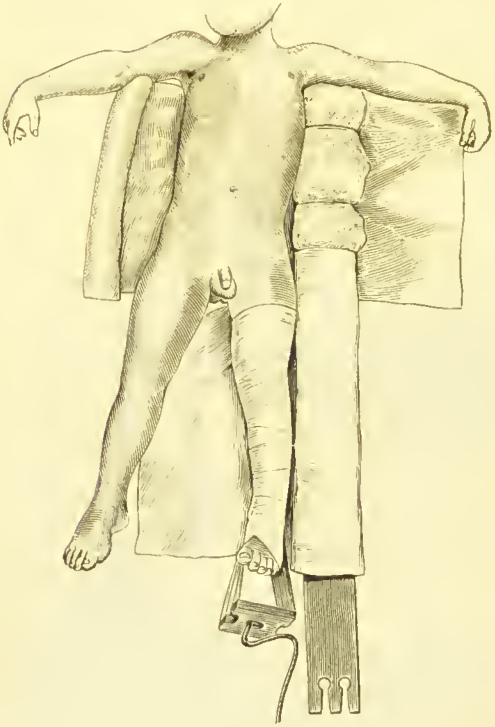
FIG. 146.—Long Splint with Extension Plasters applied for Fracture of Neck of Femur.

The joints above and below the fracture are controlled by means of *Liston's long splint*, which extends from the axilla to two or three inches beyond the foot. The part of the splint which lies in contact with the lower extremity is enclosed in a sheet which envelops the limb, while the upper part is fixed to the thorax by means of a broad roller bandage. Rotation of the limb is prevented by fixing the lower end of the splint in a foot rest. It is often an advantage to apply a long splint to the sound leg in addition, and to connect the two splints by a cross-bar below.

Hodgen's splint (Fig. 150) may also be employed in the treatment of these fractures.

When these methods are not available, or when the patient has to be transported, extension may be obtained by means of a *perineal band* attached to *Liston's long splint* (Fig. 147). The patient's foot, carefully padded, is fixed to the lower end of the splint by means of a bandage or triangular handkerchief. By pushing the splint down traction is made upon the limb, and this is maintained by means of a padded triangular bandage passed through the perineum and fixed to the upper end of the splint. This method is less efficient and more uncomfortable than that by weight and pulley.

Eversion may be corrected by sand-bags placed alongside the limb; or by means of a piece of wood fixed to the back of the knee at right angles to the axis of the limb by a few turns of plaster-of-Paris bandage. It is important also to keep the bed-clothes clear of the foot by means of a cage.

The retentive apparatus is worn for about six weeks, after which the patient is allowed to go on crutches.

In view of the unsatisfactory results obtained by the ordinary methods of treating fractures through the narrow part of the neck, recourse may be had to accurate fixation of the fragments to one another by means of a long steel peg introduced through the skin over the great trochanter, and passed so as to transfix the two fragments.

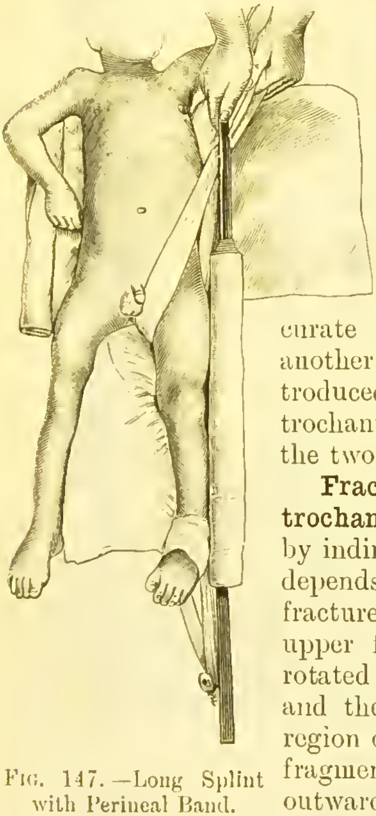

FIG. 147.—Long Splint with Perineal Band.

Fracture immediately below the lesser trochanter may be produced by direct or by indirect violence, and the displacement depends largely on whether the line of fracture is transverse or oblique. The upper fragment is tilted forward and rotated outward by the ilio-psoas muscle and the external rotators inserted in the region of the great trochanter. The lower fragment is pulled upward and rotated outward by the flexors and adductors, the weight of the limb aggravating the eversion. The tilting of the upper fragment may be increased by the lower fragment pushing it forward.

On account of the difficulty of controlling the short upper fragment, union is liable to take place with considerable shortening and deformity (Fig. 148).

Treatment.—When it is found, under chloroform, that the displacement can be completely reduced, and the fragments kept in accurate apposition by carefully padded local splints, this fracture is treated on the same lines as fractures of the shaft of the bone.

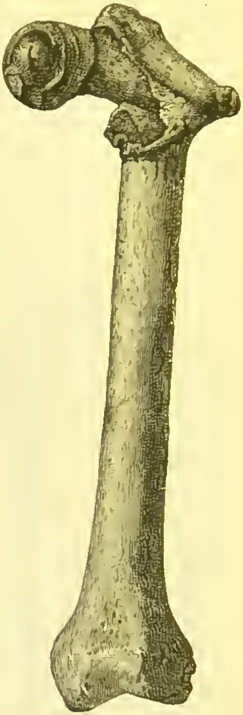

Fig. 148.—Fracture of Femur just below the Small Trochanter showing flexion and external rotation of upper fragment.

In cases in which the upper fragment cannot be brought into line with the lower one, however, it is necessary to flex and slightly rotate outward and abduct the thigh in order to get the fragments into apposition. This is most simply done by means of a double-inclined plane, while at the same time extension may be applied in the axis of the thigh. Hodgen's splint fulfils these indications. It has the advantage of permitting of the patient being moved or even propped up in bed without fear of disturbing the fracture.

The apparatus consists of a wire frame to one side of which a series of strips of flannel about four inches wide are attached. The frame, which extends from the level of Poupart's ligament to well beyond the sole, is placed over the front of the limb, and the loose ends of the flannel strips, brought round behind the limb, and fixed to the other side of the frame, convert it into a sling. The strips of flannel may be replaced with advantage by a strong, wide-meshed net. Extension strapping is applied to the limb in the usual way, and is attached to the lower end of the frame. By suspending the limb in this splint by means of cords passing obliquely over a pulley attached to an upright at the foot of the bed, the weight of the limb is made to act as the

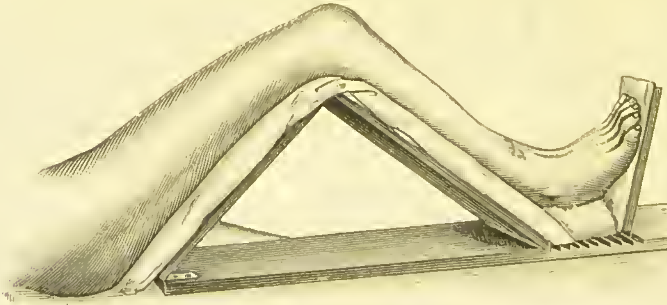

Fig. 149.—Double-inclined Plane.

extending force. It should be kept on for six or eight weeks, after which a plaster-of-Paris spica is applied, and the patient allowed to walk on crutches for three or four weeks longer.

Dislocations of the Hip.

It is unnecessary for our present purpose to attempt a comprehensive classification of the numerous varieties of dislocation which have been met with at the hip-joint.

It will suffice if we divide them into those in which the head of the femur passes backward, and comes to rest on the dorsum ilii (*dorsal dislocation*), or in the ischiatic notch (*ischiatic dislocation*); and those in which it passes forward and comes to rest in the obturator foramen (*obturator* or *thyroid dislocation*), or on the pubes (*pubic dislocation*).

The backward are much more common than the forward dislocations, in contrast to those at the shoulder, where the forward varieties predominate.

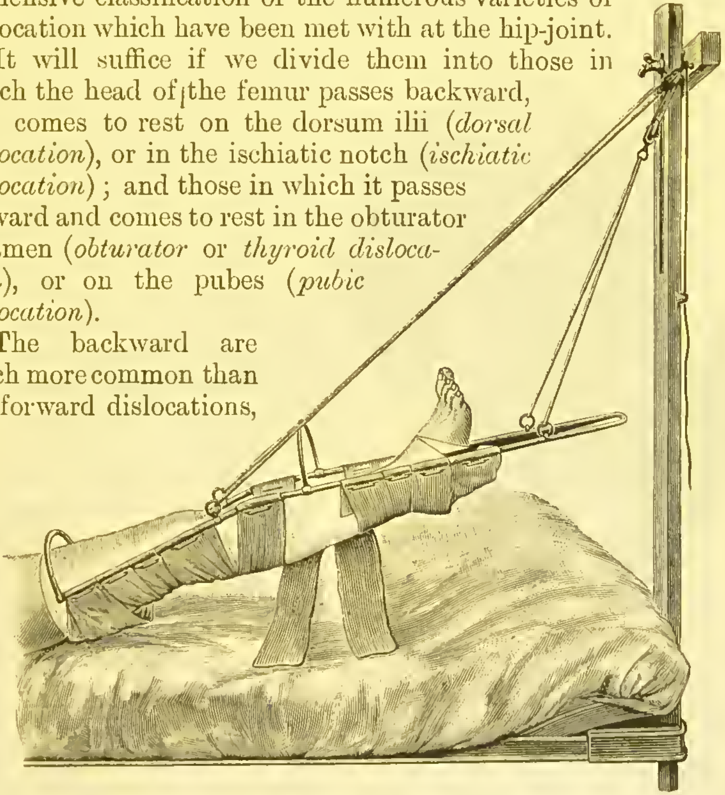

Fig. 150.—Hodgen's Splint.

On account of the great strength of the hip-joint, dislocation is by no means a common injury. It is usually met with in strong adults after the epiphyses have ossified, and before the bones have commenced to become brittle; and it is much more common in men than in women. It is invariably the result of severe violence, the limb at the moment being in such a position that the ligaments are on the stretch and the muscles taken at a disadvantage. The head of the femur usually leaves the joint at the lower and back part, where the socket is shallowest and the ligaments weakest. The ligamentum teres is almost always torn from its femoral attachment, and one or more of the muscles inserted in the region of the trochanters may be ruptured. The λ-shaped ligament, on the other hand, is seldom torn, and so long as it remains intact the dislocation belongs to one or other of the types above-named. All atypical dislocations, such as the supra-cotyloid, infra-cotyloid, ilio-pectineal, or dislocation on to the ischial tuberosity, are due to rupture of some part of the λ-ligament, and are so rare as not to call for individual description.

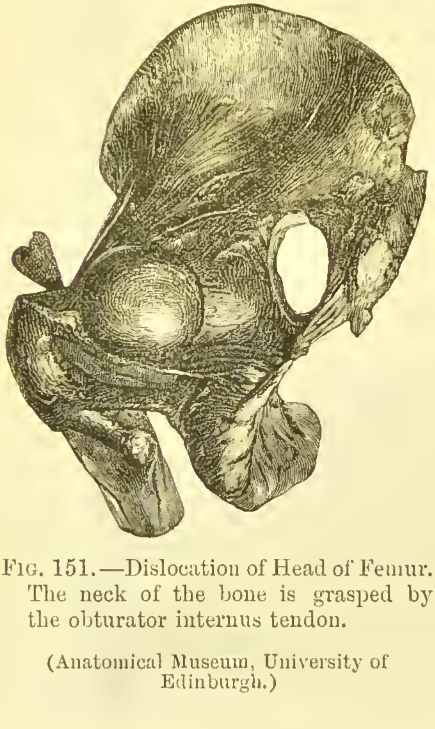

FIG. 151.—Dislocation of Head of Femur. The neck of the bone is grasped by the obturator internus tendon.

(Anatomical Museum, University of Edinburgh.)

Like other dislocations, those of the hip may be complicated by laceration of muscles, blood-vessels, or nerves, or by fracture of one or other of the bones in the vicinity.

Dislocation onto the Dorsum Ilii.—This, the commonest form of dislocation of the hip, is usually the result of the patient falling from a height, or receiving a heavy weight on the back while stooping forward with the thigh flexed, adducted, and rotated in. It is also said to occur from muscular action. The shaft of the femur acts as the long limb of a lever of which the neck is the short limb, while the femoral attachment of the λ-ligament forms the fulcrum. The head, thus brought to bear upon the lower and back part of the capsule, tears it and leaves the socket, passing upwards in front of the tendon of the obturator internus, and coming to rest on the back of the ilium. The articular surface is directed backward, while the trochanter looks forward.

Clinical Features.—The affected limb is flexed, adducted, and rotated inward, so that the knee crosses the lower third of the opposite thigh, and the ball of the great toe lies on the dorsum of the sound foot. There is shortening to the extent of from one and a half to two inches, the trochanter being displaced above Nélaton's line, and lying further from the anterior superior iliac spine than on the normal side. The patient is unable to move the limb or to bear weight upon it; abduction and external rotation are specially painful; and traction fails to restore the limb to its proper length. On making these attempts a characteristic elastic resistance is felt.

The head of the femur may sometimes be felt in its new position through the fibres of the gluteus maximus, but the swelling of soft parts often obscures this sign. The normal depression behind the great trochanter is lost, the gluteal fold is raised, and there is often a degree of lordosis which compensates for the flexion. The fingers can be pressed more deeply into Scarpa's triangle on the dislocated than on the normal side—a point in which this injury differs from fracture of the base of the neck of the femur.

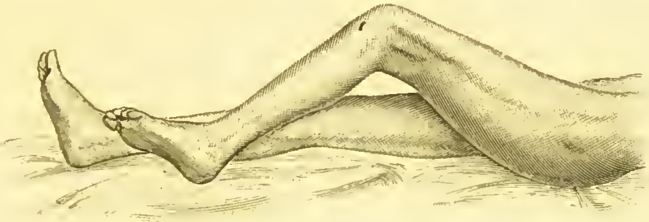

FIG. 152.—Dislocation of Femur onto Dorsum Ilii, showing flexion, adduction, and shortening of the limb.

In a certain number of cases the outer limb of the λ-ligament is ruptured and the limb is everted—*dorsal dislocation with eversion;* but in other respects the clinical features are much the same.

Dislocation into the vicinity of the Ischiatic Notch or "*dislocation below the tendon.*"—This variety of backward dislocation is less common than that onto the dorsum, although produced in the same way. The head of the femur passes beneath the obturator internus, and this tendon, catching on its neck, checks its upward movement.

The *clinical features* are the same as those of the dorsal variety, but, on the whole, are less marked.

Differential Diagnosis.—Backward dislocations of the hip are usually easily recognised. When the dislocation below the tendon occurs in a very stout person, however, it is liable to be overlooked on account of the difficulty of feeling the displaced bone, and the comparatively slight amount of deformity present.

The nature of the accident, the absence of broadening of the trochanter, and the adduction and inversion of the limb are usually sufficient to prevent a dislocation being mistaken for an impacted extra-capsular fracture.

Dislocation into the Obturator Foramen.—This dislocation is produced by great force applied from behind when the thigh is flexed and abducted, as when a weight falls on the back of a man stooping forward with the legs wide apart. It may also result from violent abduction by wide separation of the thighs.

The capsule gives way at its inner and lower part, and the head of the femur comes to rest on the surface of the external obturator muscle, being directed forward, while the trochanter looks backward.

Clinical Features.—The thigh is slightly flexed and abducted, with the foot pointing directly forward or a little everted. The body is bent forward to relax the ilio-psoas muscle and the λ-ligament, the foot is advanced and the toes pointed. It is not uncommon for the patient to be able to walk after the accident, and only to seek advice some time after on account of inability to adduct and extend the limb. There is apparent lengthening of the limb due to tilting of the pelvis downward on the affected side. The hip is flattened, the trochanter less prominent than usual, and the head of the bone may sometimes be felt in its abnormal position. It is doubtful if a rectal examination ever gives reliable information as to the position of the head of the femur.

Dislocation onto the pubes is a further degree of the obturator form. It is usually produced by forcible hyper-extension and external rotation of the hip, such as occurs when the body is bent back while the thigh remains fixed.

The capsule is torn further forward than in the other varieties, and the head rests on the horizontal ramus of the pubes against the ilio-pectineal line.

Clinical Features.—There is marked eversion, flexion, and abduction, but the shortening is inconsiderable. The ilio-psoas and λ-ligament are tense. The head of the femur may be felt in the groin, with the femoral vessels over, or to one or other side of it. There is sometimes pain and numbness in the distribution of the anterior crural nerve. The prominence of the great trochanter is lost.

Treatment of Dislocations of the Hip.—The patient should be placed on a firm mattress on the floor, to give the surgeon the best possible purchase upon the limb. Complete anæsthesia is necessary. The surgeon grasps the ankle with one hand, while

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the other is placed behind the head of the tibia, the leg being held at right angles to the thigh. An assistant, meantime, steadies the pelvis by making firm pressure over the iliac crests.

As the chief obstacle to reduction is the tension of the ilio-femoral ligament, the first indication in the reduction of any form of dislocation is to relax this structure by flexing the limb at the hip-joint.

In the *backward* varieties (dorsal and ischiatic) this is effected by fully flexing the thigh upon the pelvis in the position of adduction. The thigh is then fully abducted, to cause the head of the bone to retrace its steps forward towards the rent in the capsule; and at the same time rotated outwards, to relax the rotator muscles. This combined movement also tends to open up the rent in the capsule and to facilitate the return of the bone. Finally, the limb is quickly extended to cause the head to enter the socket. This object is often aided by making vertical traction or lifting movements on the abducted and externally rotated limb before extending.

For the reduction of the *forward* varieties (obturator and pubic) also, the thigh is first fully flexed on the pelvis, but in the abducted position. The limb is then strongly rotated inward and adducted, and finally extended. Lifting movements are also found useful in many of these cases.

All methods of reduction by forcible traction on the extended limb are to be avoided, as they fail to meet the primary indication of relaxing the λ-ligament.

After reduction the limb is steadied by a sand-bag, massage and movement being carried out after the first few days. The range of movement is gradually increased, and the patient is allowed to use the limb with caution in from three weeks to a month.

When the rim of the acetabulum has been fractured, the patient must be confined to bed with extension and a long splint for eight or nine weeks, to avoid the risk of redislocation.

Changes of the nature of chronic arthritis are liable to occur in and around the joint in old and rheumatic subjects; and atrophy or paralysis of muscles supplied by the injured nerves may follow.

Old-standing Dislocations.—It is impossible to lay down any time limit for attempting reduction in old-standing dislocations of the hip. Manipulation may succeed in cases of some months' standing, and may fail where the bone has only been out for a few weeks. In certain cases, even after reduction has been effected, there is a marked tendency to redisplacement. In any case, the attempt does good by breaking down adhesions, provided no undue force is employed such as may damage the sciatic nerve or vessels, or fracture the neck of the femur. In young subjects, in whom the deformity is great and the usefulness of the limb seriously impaired, the head of the bone should be excised; but if the head has formed a new socket for itself and there is a fairly useful joint, the condition should be left alone.

Congenital Dislocations of the Hip are described with deformities.

Sprains of the hip are comparatively rare. They result from milder degrees of the same forms of violence as produce dislocation. The ligaments are stretched or partially torn, and there is considerable effusion of fluid into the joint. Pressure over the joint elicits tenderness; and the limb assumes the position of slight flexion, abduction and external rotation, but there is no alteration in the length of the limb. Such injuries, unless carefully treated, are apt to be followed by stiffness of the joint due to the formation of adhesions.

Contusions in this region, on the other hand, are not uncommon. They are produced by a fall on the trochanter such as may cause fracture of the neck of the femur in old people, and give rise to symptoms which simulate to some extent those of this fracture. The limb lies in the position of slight flexion, but the bony points retain their normal relationship to one another, and there is no actual shortening. The swelling and tenderness often prevent a thorough examination being made, and when any doubt remains as to the diagnosis, the patient should be kept in bed till the doubt is cleared up. If a fracture has occurred it will reveal itself in the course of a few days by the occurrence of shortening and other evidences of fracture.

In elderly patients contusions of the hip may be followed by changes in the joint of the nature of those described as arthritis deformans; and it has been stated, although proof is wanting, that absorption of the neck of the femur sometimes occurs. These injuries are treated by rest in bed, massage, and the other measures already described as applicable to sprains and contusions.

FRACTURES OF THE SHAFT OF THE FEMUR.

This group includes all fractures between that immediately below the trochanter minor and the supra-condylar fracture.

When due to direct violence the fracture is usually transverse, and in infants and children, in whom it is more common than in adults, it may be sub-periosteal with little or no displacement. Indirect violence, on the other hand, usually produces complete and oblique fractures, which are frequently comminuted and often compound. The break is most commonly situated a little above the middle of the shaft, the obliquity being downward, forward and inward, and of such a nature that the fragments tend to override one another.

The direction and nature of the displacement depends more upon the action of the muscles attached to the respective fragments, the fracturing force, and the weight of the lower part of the limb, than upon the direction of the obliquity. As a rule the upper fragment is pulled forward and outward by the ilio-psoas and glutei muscles, while the lower fragment is displaced upward and inward, and is rotated outward by the combined action of the longitudinal muscles of the thigh, the adductors and the weight of the limb.

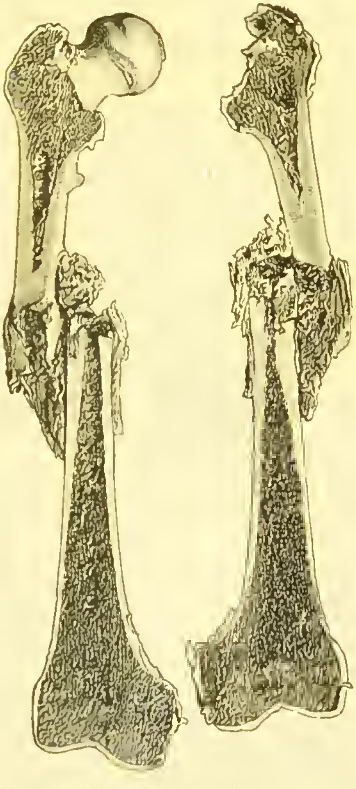

FIG. 153. — Recent Fracture of Shaft of Femur with overriding of Fragments.

Clinical Features.—The limb is at once rendered useless, and there is great swelling from effusion of blood in the region of the fracture. This, together with the muscularity of the part, often renders an accurate diagnosis as to the site and direction of the fracture exceedingly difficult. When the fracture is produced by indirect violence there is often an effusion into the knee-joint. The shortening varies from half an inch to three or four inches—averaging about one inch in adults. Eversion is always marked, and mobility and crepitus may be elicited by placing the hand under the seat of fracture and gently attempting to lift the limb; or by fixing the upper fragment by one hand placed in front and carefully lifting the lower part of the limb. It will be found that the great trochanter does not rotate with the lower segment of the femur. These tests must be employed with great caution lest the deformity be increased or the fracture be rendered compound.

In children, especially below the age of ten, this fracture is of very common occurrence. It is often of the greenstick variety, or, if complete, is transverse and sub-periosteal, so that it is accompanied by few symptoms and but little deformity. It is therefore liable to be overlooked.

Prognosis.—The patient must be confined to bed for six or eight weeks (children for three or four), and should use a retentive apparatus and crutches for three or four weeks longer, before bearing his weight upon the limb. The old dictum of Nélaton that the treatment of fracture of the thigh should last for a hundred days is a safe working-rule.

In cases of oblique fracture the patient should be warned that, however successful the treatment may be, shortening to the extent of from three-quarters to one inch is liable to result. This does not necessarily imply a permanent limp, as by tilting the pelvis he may be enabled to walk quite well.

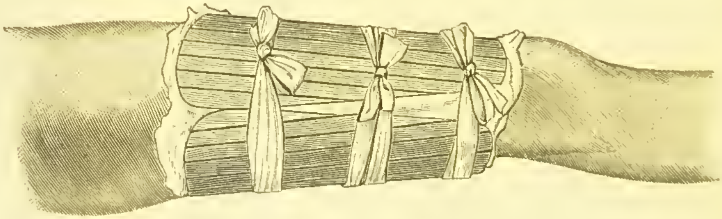

FIG. 154.—Local Gooch Splints applied for Fracture of Shaft of Femur. The splints reach to the fold of the buttock.

Union is often exceedingly slow in fracture of the femur, and may even be delayed for months. It is also common to meet with malunion, the fracture uniting with an angular deformity outward and forward. If the patient falls refracture may easily occur, and is not uncommon within some months of the original injury.

In many fractures of the thigh, and especially in those produced by indirect violence, there is a considerable effusion into the knee-joint which often leads to prolonged stiffness.

Treatment.—Reduction should be effected under an anæsthetic. Extension strapping is then applied well above the seat of the fracture, and the seat of fracture is enclosed in a ferrule of Gooch splinting (Fig. 154), and a double long splint applied. It is often necessary to employ as much as ten or twelve pounds or more to maintain extension after reduction. Massage should be employed after the first week. The retentive apparatus should be worn for from six to eight weeks, after which the patient is allowed up with crutches. The limb may be secured in a Thomas' hip splint or a plaster-of-Paris case extending round the pelvis. In fractures near the lower end of the shaft a Thomas' knee splint suits very well. This must be worn for three or four weeks.

An efficient means of treating this fracture is by Hodgen's splint.

In infants and young children the nursing is greatly facilitated by applying vertical extension to both lower extremities. The fracture being usually transverse and showing little tendency to displacement, the local Gooch splints may often be dispensed with, or replaced by a few turns of starch bandage.

Operative treatment is sometimes called for when simpler measures fail to reduce the displacement, and in cases of vicious union or ununited fracture. The incision, which must be free, is preferably placed on the outer aspect of the limb; the periosteum is interfered with as little as possible; and the ends of the bones are pegged, screwed or wired according to circumstances. The after treatment is carried out on the same lines as for simple fracture, but the retentive apparatus must be worn for a considerably longer period.

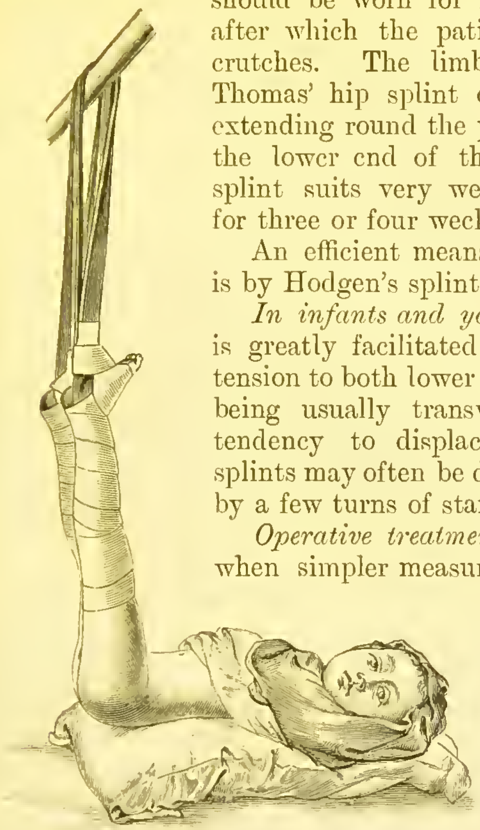

FIG. 155.—Fracture of Thigh treated by Vertical Extension.

CHAPTER XXVI.

INJURIES IN THE REGION OF THE KNEE AND LEG.

Surgical Anatomy—FRACTURES OF LOWER END OF FEMUR: *Supra-condylar; T- or Y-shaped; Separation of epiphysis; Either condyle*—FRACTURES OF UPPER END OF TIBIA: *Of head; Separation of epiphysis; Avulsion of tubercle of tibia*—DISLOCATIONS OF KNEE: *Dislocations of superior tibio-fibular joint*—INTERNAL DERANGEMENTS OF KNEE—INJURIES OF PATELLA: *Fractures; Dislocations*—INJURIES OF LEG: *Fracture of both bones; Fracture of tibia alone; Fracture of fibula alone.*

INJURIES IN THE REGION OF THE KNEE.

THESE include the supra-condylar fracture of the femur, the T- or Y-shaped fracture opening into the joint, separation of the lower femoral epiphysis; fracture of the head of the tibia, and separation of its upper epiphysis; the various dislocations and sprains of the knee, as well as its internal derangements; and fractures and dislocations of the patella.

Surgical Anatomy.—Of the two condyles the internal is the more prominent and palpable. On its upper edge is situated the adductor tubercle, which gives attachment to the round tendon of the adductor magnus, and which marks the level of the epiphysial line, and the upper limit of the trochlear surface of the femur. Between the internal condyle and the inner tuberosity of the tibia a furrow can be recognised, especially in the flexed position, and in it the anterior end of the internal semilunar cartilage may be felt. The outer tuberosity of the tibia can also be palpated, and must not be mistaken for the head of the fibula, which lies farther back and at a slightly lower level, and can readily be identified by tracing to it the tendon of the biceps. The tubercle of the tibia, into which the quadriceps extensor tendon is inserted, lies on the same level as the head of the fibula. In the extended position of the limb the patella is seen and felt on the front of the trochlear surface of the femur, in which position it is loose and movable, and presents a hollow on each side of it. In flexion it sinks between the condyles, resting chiefly on the outer one and becoming fixed.

The popliteal artery and vein, and the internal popliteal nerve lie in close relation to the posterior aspect of the joint; and the external popliteal nerve passes behind and to the inner side of the biceps tendon.

The knee is an example of a joint which depends for its strength chiefly on its ligaments. Not only are the external and internal lateral ligaments and the posterior part of the capsular ligament particularly strong, but the crucial ligaments and the semilunar cartilages inside the cavity of the joint further add to its stability. The powerful tendon of the quadriceps extensor muscle, in which the patella is developed as a sesamoid bone, protects and strengthens the front of the joint.

The synovial cavity extends from the level of the head of the tibia to an inch or more above the trochlear surface of the femur, passing slightly higher on the inner aspect of the joint than on the outer (Fig. 232). The large bursa between the quadriceps muscle and the femur generally communicates with the cavity of the joint. The synovial cavity of the superior tibio-fibular articulation is usually distinct from that of the knee-joint, but may communicate with it through the popliteal bursa.

A large bursa (*prepatellar*) lies over the lower part of the patella and upper part of the ligamentum patellæ; and a smaller one separates the ligamentum patellæ from the tubercle of the tibia. Several important bursæ are found in the popliteal space, one of which—the semi-membranosus bursa—sometimes communicates with the knee-joint.

FRACTURES OF THE LOWER END OF THE FEMUR.

Supra-condylar fracture of the femur is usually the result of a fall on the feet or knees, or of direct violence. It is most common in adults. The line of fracture is generally irregularly transverse, or it may be slightly oblique from above downwards and forwards, so that the upper fragment passes forward towards the patella, while the lower is rotated backward on its transverse axis by the gastrocnemius muscle.

The **T- or Y-shaped fracture** is, as a rule, produced by direct violence, the force first breaking the bone above the condyles, and then causing the upper fragment to penetrate the lower and split it up into two or more pieces. The main fissure is usually through the inter-condylar notch, and sometimes the lower end of the bone is severely comminuted.

Separation of the lower epiphysis is a comparatively common injury. It occurs usually in males between the ages of thirteen and eighteen, as a result of severe violence such as results from the limb being caught between the spokes of a revolving wheel, or from hyper-extension of the knee. It has also been produced in attempting to rectify knock-knee and other deformities in this region. As a rule there is little displacement of the loose epiphysis, but it may pass in any direction, forward being the most common.

Either *condyle* may be broken off without the integrity of the shaft being destroyed, by a direct blow or fall on the knee, or by violent twisting of the leg. The separated condyle may not be displaced, or it may be pushed upwards or rotated on its transverse axis.

Clinical Features.—When the line of fracture traverses the joint there is an immediate effusion of blood into the synovial cavity. In fractures which are strictly extra-capsular there is frequently a copious effusion of serum into the joint. The region of the knee, therefore, is greatly swollen, and the recognition of the precise nature of the injury is rendered difficult. As it is of the utmost importance to arrive at an accurate diagnosis, a general anæsthetic should be given when necessary for this purpose.

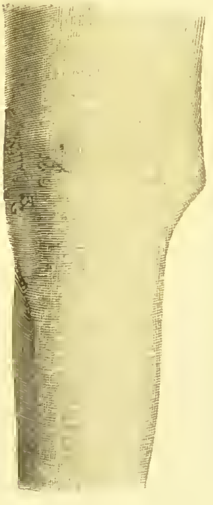

FIG. 156.—Separation of Lower Epiphysis of Femur, showing backward projection of lower end of diaphysis.

In the *supra-condylar fracture* the upper end of the lower fragment is usually palpable in the popliteal space, while the upper fragment is unduly prominent in front. By flexing the knee the fragments may be brought into apposition and crepitus elicited. In oblique fractures the pointed lower end of the upper fragment may transfix the quadriceps extensor muscle and may be felt under the skin. It sometimes perforates the skin and thus renders the fracture compound. It should be disengaged by fully flexing and making traction on the knee. The thigh is shortened to the extent of from a half to one inch.

In the T- *or* Y-*shaped fracture* the knee is broadened, and pain and crepitus are readily elicited on moving the condyles upon one another, or on pressing them together. On moving the patella transversely it may be felt to hitch against the edge of the fractured condyle. The shortening may amount to one or two inches.

In *epiphysial separations* the age of the patient, the mode of injury, the finding of the smooth broad end of the diaphysis in the popliteal space, and the difficulty in reduction and retention usually serve to establish the diagnosis. Crepitus is of little or no value as a diagnostic sign.

In fracture of *one or other condyle* there is broadening of the knee but no shortening of the thigh, and the ecchymosis, crepitus, and pain are localised to the affected side. The knee can usually be moved to an abnormal extent towards the injured side.

Prognosis.—The difficulty of controlling the short fragment in these injuries renders accurate apposition and union without shortening very uncertain, and the effusion into the joint which so constantly occurs is liable to lead to stiffness. This is especially liable to occur in the T- or Y-shaped fractures. After an epiphysial separation the growth of the limb is sometimes, although not always, interfered with.

The popliteal vessels lie so close to the bone, that they are liable to be pressed upon or even torn by the displaced lower fragment. When this occurs there is great swelling in the region of the knee, with loss of pulsation in the anterior and posterior tibial arteries, and not infrequently gangrene of the limb ensues. There may also be injurious pressure on the nerves.

Amputation may be called for when these complications exist, or when gangrene or severe septic conditions threaten the life of the patient.

Treatment.—Fractures in the region of the knee, especially the supra-condylar and T-shaped fractures, often present great difficulties in treatment. The small size of the lower fragment, its depth from the surface, and the accompanying effusion into and around the joint, render its control difficult if not impossible. In the majority of cases the two fragments can only be brought into apposition when the knee is flexed on the thigh and the thigh on the pelvis, and it is almost always necessary to carry out the reduction under anæsthesia.

In the few cases where the fragments can be accurately approximated in the extended position of the limb, retention may be effected by means of a box-splint reaching well up the thigh.

In the majority, however, flexion is necessary, and the limb must be fixed on a double inclined plane, so constructed that the angle of flexion can be adjusted to meet the requirements of the individual case. If the lower fragment is of sufficient length to permit of extension strapping being applied to it, extension by weight and pulley, acting in the axis of the femur, and carried over an upright at the foot of the bed, may be useful. In most cases, however, this is impracticable.

A poroplastic splint moulded over the front of the limb and secured by bandages is a valuable aid in maintaining accurate apposition of the fragments, which, unless so secured, are very liable to become redisplaced.

Hodgen's splint, bent nearly to a right angle, is also found useful in the treatment of these injuries.

A careful watch must be kept on the circulation of the limb during the first few days, lest it be interfered with by the pressure of the apparatus.

In a considerable number of cases these means of retaining the fragments in apposition prove ineffectual, and it is necessary to have recourse to operative measures, mechanically securing the fragments by nails, screws, or wire sutures, after exposing the seat of fracture. Such operations entail opening the cavity of the joint—hence the occurrence of septic infection may prove disastrous.

Division of the tendo Achillis is not to be recommended as a means of combating the backward tilting of the lower fragment. In all cases the retentive apparatus must be worn for about six or eight weeks, but movement and massage should be employed as soon as possible, as persistent stiffness of the knee is one of the most troublesome sequelæ of these injuries.

Compound and complicated fractures are dealt with on the general principles governing the treatment of such injuries. Amputation may become necessary should gangrene ensue.

Operative interference may be called for to rectify deformities resulting from malunion.

Fractures of the Upper End of the Tibia.

Fracture of the head of the tibia is a comparatively rare injury. It may result from a direct blow, such as the kick of a horse, or from indirect forms of violence. The line of fracture may be transverse or oblique. Occasionally the lower fragment is impacted into the upper and causes comminution. One or other of the tuberosities may be chipped off by forcible adduction or abduction at the knee. Transverse fracture of the head of the fibula sometimes accompanies fracture of the head of the tibia.

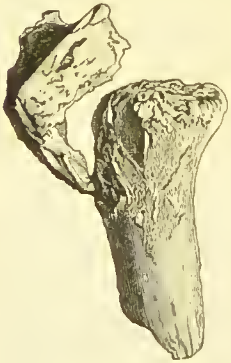

Fig. 157.—Separation of Upper Epiphysis of Tibia in a boy aet. 15.

The displacement varies with the nature of the break, and there is always considerable effusion into the knee-joint.

The ordinary clinical features of fracture are well marked, and the diagnosis is easy. From some unexplained reason this fracture usually takes a very long time, sometimes several months, to consolidate.

Separation of the *upper epiphysis* of the tibia, which includes the tongue-like process for the tubercle, and the facet for the fibula, is also rare. It usually occurs between the ages of three and nine. The displacement is forward or lateral, and is accompanied by the usual signs of such lesions. The growth of the limb is sometimes arrested, and shortening and angular deformity may result (Fig. 158).

Treatment.—After being reduced under an anæsthetic these fractures are usually satisfactorily treated in a box splint (Fig. 168), carried sufficiently high to control the knee-joint. When the head of the tibia is comminuted light weight extension—three or four pounds—is beneficial. Movement and massage are commenced within a few days, and at the end of a fortnight the patient is allowed up with crutches, wearing a moulded splint of poroplastic, or plaster of Paris.

Avulsion of the *tubercle of the tibia* occasionally occurs in youths, from violent contraction of the quadriceps—as in jumping. The limb is at once rendered powerless, and the osseous nodule can be felt, and on moving it crepitus is elicited.

This is best treated by pegging the tubercle in position, and fixing the limb on an inclined plane to relax the quadriceps muscle.

The *upper end of the fibula* is seldom broken alone. Its chief clinical interest lies in the fact that it may implicate the musculo-cutaneous branch of the external popliteal nerve.

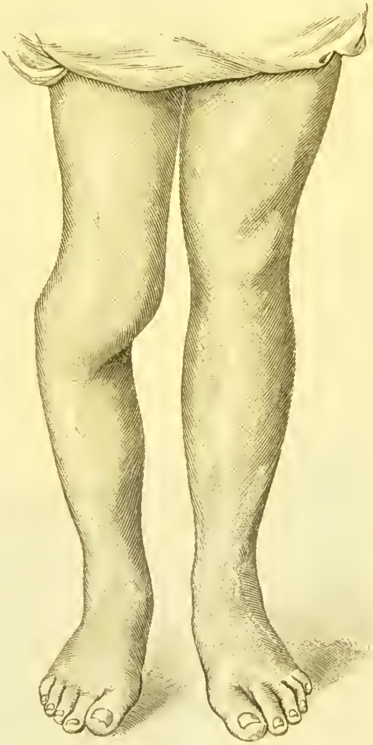

FIG. 158.—Separation of Upper Epiphysis of Tibia of old standing.

DISLOCATIONS OF THE KNEE.

Dislocation of the knee occurs only as a result of extreme degrees of violence, especially of a wrenching or twisting character.

Antero-posterior dislocations are more common than those which are lateral, and are more frequently complete. A considerable proportion of all varieties are compound, and the damage to the contents of the popliteal space is often so great as to necessitate primary amputation.

The varieties are named in terms of the direction in which the tibia passes.

Dislocation *forward* is the most common variety (Fig. 159), and results from sudden hyper-extension of the knee. It is often compound through a wound in the popliteal space. The leg remains fully extended, and lies on a plane anterior to that of the thigh.

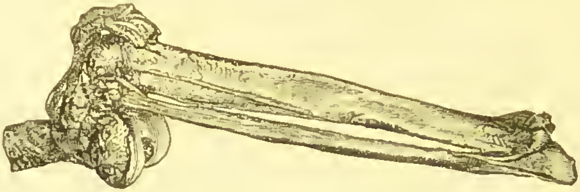

FIG. 159.—Forward Dislocation of Knee.
(Specimen in Professor Annandale's collection.)

The condyles are distinctly palpable posteriorly, and the skin is tightly stretched over them, or may even be torn. The patella is projected forward, and the skin above it is thrown into transverse folds.

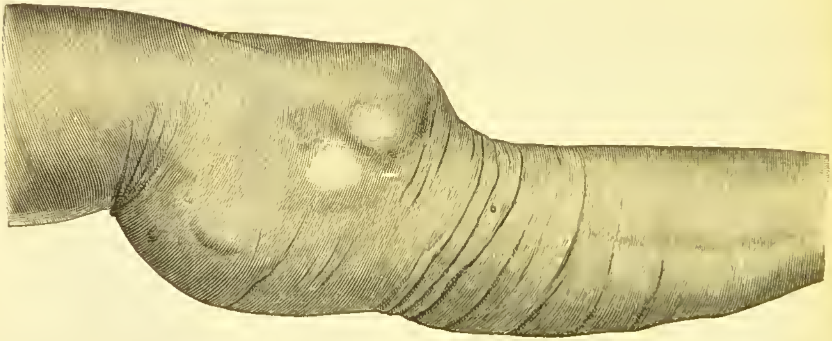

FIG. 160.—Backward Dislocation of Knee.
(Dr. Mills-Roberts' Case.)

Dislocation *backward* is usually due to a direct blow driving one of the bones past the other. The leg remains hyper-extended, the head of the tibia occupies the popliteal space, while the lower end of the femur projects forward with the patella either in front or to one side of it.

The lateral dislocations are generally incomplete. In the *inward* variety the outer condyle forms a prominence, with a depression over the head of the tibia and fibula; in the *outward*, the bones of the leg project outward, the depression being above them.

Treatment.—If the patient is fully anæsthetised reduction can usually be effected by manipulating the bones into position while traction is made on the leg and counter-traction on the thigh, with the knee in the flexed position.

These dislocations differ from most others in that no special manipulations are necessary to restore the displaced bone to its place, and that reduction does not take place with a distinct snap.

In antero-posterior dislocations the limb should be flexed and placed on a pillow, movement and massage being employed from the first. The patient is usually able to walk about within a month.

In lateral dislocations there is at first considerable tendency to re-displacement, and it is therefore necessary to secure the joint in a box splint for about fourteen days, after which massage and movement are employed. It is usually about six weeks before the patient can use the limb with freedom.

In compound dislocations, and in those complicated by injury to the popliteal vessels, the question of amputation has to be considered.

Dislocation of the Superior Tibio-Fibular Articulation.—This joint may be dislocated by twisting forms of violence applied to the foot or leg, or by forcible contraction of the biceps muscle. The displacement may be forward or backward, and the head of the fibula can be felt in its new position with the prominent tendon of the biceps attached to it. The movements of the knee are quite free, but the patient is unable to walk on account of pain. Reduction and retention are, as a rule, easy, and the ultimate result of treatment satisfactory. We have frequently met with this injury accompanying compound fractures of both bones of the leg resulting from railway and similar accidents.

By applying direct pressure over the displaced bone, with the knee flexed, the dislocation is easily reduced. It is kept in position by a few strips of plaster, a firm bandage or a light rigid splint, such as poroplastic or Croft's plaster of Paris splint.

Very rarely the fibula is separated from the tibia at both ends (*total dislocation*) and displaced upwards. Bennett of Dublin has pointed out that in some individuals the upper end of the fibula does not reach the facet on the tibia—a condition which might be mistaken for a dislocation.

Displacement of the Semilunar Cartilages.

One or other of the semilunar cartilages may become unduly movable as a result of gradual stretching of its ligaments, or may be actually displaced by sudden rupture of these. The most common condition is one in which the ligaments of the affected side of the joint are relaxed and admit of the cartilage passing between the bones, so that it is liable to be nipped in certain movements of the joint. When the ligaments are completely torn the cartilage may be dislocated into the inter-condyloid notch. We have seen one case in which it was protruded from the joint.

In other cases the cartilage itself is actually torn across—usually near its anterior end, with the result that the posterior part is liable to pass between the bones. Not infrequently the cartilage is split longitudinally, so that its inner margin becomes loose.

The internal cartilage is much more frequently affected than the external. This is largely due to the fact that, owing to the way in which it is fixed by its coronary and other ligaments to the capsule of the joint, it enjoys a comparatively limited range of movement. When the knee is flexed, therefore, and the tibia suddenly rotated outward, these ligaments are put upon the stretch and are liable to give way and allow the cartilage to slip too far inwards between the articular ends of the bones. This condition is met with most frequently amongst those who by their occupation are compelled to assume a kneeling or squatting attitude, with the toes turned outward, for prolonged periods—as is the case, for example, with coal-miners. The ligaments attaching the semilunar cartilage to the capsule, and the lateral ligaments of the joint are gradually stretched and weakened, so that a comparatively slight degree of violence may be sufficient to determine displacement. It is seldom met with in females.

The determining cause of the displacement is usually some sudden movement which tends to rotate the leg outward—a movement which is only possible when the joint is in the partially flexed position. It frequently happens in the course of such exercises as tennis, football, golf and skating, when the player turns quickly round and pushes off with the foot. It may also occur from slipping off the kerb-stone. The mechanism by which this lesion is produced doubtless explains the greater frequency with which the left knee is affected, as most sudden movements are made from right to left, thus throwing the strain upon the left knee.

Clinical Features.—The surgeon may be consulted either the first time the displacement occurs, or on account of its repeated recurrence. In the former case he will obtain the history that while making some sudden movement, the patient was seized with an intense, sickening pain in the knee, accompanied, it may be, with a sensation of something giving way with a distinct crack, and followed by locking of the joint. The patient usually falls and may be unable to rise again. The knee is found to be fixed in a sightly flexed position; complete extension is impossible on account of the cartilage being wedged between the articular surfaces of the femur and tibia, but flexion is usually comparatively easy. Tenderness is elicited on making pressure over the position of the anterior attachment of the cartilage—that is, at the inner edge of the ligamentum patellæ in the groove between the femur and tibia. The pain is increased on attempting to extend the joint. Considerable effusion rapidly takes place into the synovial cavity. As a rule little is to be learned by palpation, although in exceptional cases an undue prominence may be felt, and in others a hollow, depending upon whether the cartilage has slipped outside the joint or towards its interior.

In cases of *recurrent* displacement each attack is accompanied by symptoms similar in kind to those above described, but less severe, and the patient has usually learned to carry out some manipulation by which he is able to return the cartilage into position. He seeks advice with a view to having something done to prevent displacement occurring, and to restore the stability of the joint, which, in many cases, is impaired, preventing him following his occupation.

Differential Diagnosis.—A displaced cartilage is to be diagnosed from a loose body in the joint, free or pedunculated, and from a sprain of the internal or external lateral ligament. In the differential diagnosis, the history of the condition and the site of tenderness are the most valuable guides. In the case of a displaced cartilage the pain is always referred to the same spot, while in other forms of loose body it may be at any part of the joint and varies in different attacks.

Treatment.—The patient is placed on a couch and reduction of the displaced cartilage is attempted by first fully flexing the knee, then firmly rotating the leg—inwards in the case of the internal cartilage, outwards in the case of the external,—and finally suddenly extending the joint, keeping up the rotation at the same time. Alternate flexion and extension with rotatory movements is sometimes successful. Several attempts are often necessary, and a general anæsthetic may be called for. After reduction the limb is fixed with sandbags, and massage and movement employed, great care being taken that no rotatory movement is permitted at the knee. Prolonged rest and support are necessary to allow of repair of the torn ligaments. When the patient begins to use the joint he must be careful to avoid movements which throw strain on the weak ligaments.

In *recurrent cases* attempts may be made to retain the cartilage in position by pads, bandages, or other forms of apparatus so combined as to prevent rotation taking place at the knee. In the majority of cases, however, the best results are obtained by exposing the cartilage by an incision in its long axis, and stitching it to the capsule or periosteum over the head of the tibia, or excising it, in whole or in part, as may be necessary. The capsule is closed by a row of buried catgut sutures, and the wound stitched without drainage.

Rupture of the Crucial Ligaments.—A few cases have been recorded in which, as a result of severe twisting forms of violence, the crucial ligaments have been torn from their attachments, leaving the joint loose and unstable, so that the tibia and the femur may be moved laterally on one another. Where the disability persists the joint may be opened and the ligaments sutured in position (Mayo-Robson).

Sprains of the knee are comparatively common as a result of sudden twisting or wrenching of the joint. In addition to the stretching or tearing of the ligaments, there is usually a considerable effusion of fluid into the synovial cavity. The swelling which results fills up the hollows on either side of the patella, and extends for some distance in the synovial pouch underneath the quadriceps tendon. The patella is raised from the front of the femur by the collection of fluid in the joint—" floating patella." If firmly pressed upon, the patella may be made to rap against the trochlear surface.

A sprain is to be diagnosed from separation of one or other of the adjacent epiphyses, fractures involving the articular ends of the bones, and displacement of the semilunar cartilages. On account of the swelling, which obscures the outline of the part, the differential diagnosis is often very difficult. Chief reliance is to be placed upon the bones retaining their normal relationships, and upon the fact that the points of maximum tenderness are over the attachments of the lateral ligaments. As the internal lateral ligament suffers most frequently, the most tender spot is usually over its attachments to the inner aspect of the head of the tibia—less frequently over the internal condyle.

Unless efficiently treated a sprain of the knee is liable to result in weakness of the joint, associated with effusion of fluid in the synovial cavity (*traumatic hydrops*). This is more likely to occur if the joint be repeatedly subjected to slight degrees of violence, such as are liable to occur in football or other athletic exercises—hence the name "footballer's knee" sometimes applied to the condition.

Treatment.—In recent and severe cases the patient must be confined to bed. The severe pain which accompanies the injury may be allayed by the application of very hot water, or by an ice-bag. To prevent or arrest effusion, firm elastic pressure over a thick pad of cotton wool is useful. Massage and movement should be commenced at once and carried out assiduously to promote absorption of the effusion and prevent the formation of adhesions. Prolonged fixation in rigid splints leads to stiffness, and may necessitate the use of an anæsthetic to restore the movements of the joint.

In the chronic form the best results are obtained by rest and blistering. When the patient is unable to lie up, massage should be systematically employed, and a firm elastic bandage should be worn.

INJURIES OF THE PATELLA.

Fracture of the patella is a comparatively common injury in adult males. It may result from direct violence, such as a kick or a fall on the knee, and the fracture is then vertical, oblique, or comminuted. More frequently, however, the patella is snapped across the lower end of the femur by a sudden and forcible contraction of the quadriceps extensor muscle taking place while the limb is partially flexed—as, for example, in the attempt to save one's self from falling backward. The line of fracture, which is transverse or slightly oblique, crosses the bone a little below its middle. Fractures of the patella are seldom compound unless from severe violence, such as the kick of a horse.

Chief interest attaches to the *transverse fracture*, in which the degree of displacement depends upon the extent to which the lateral expansions of the quadriceps tendon are lacerated.

As a rule they are but slightly torn, so that the separation of the fragments does not exceed an inch. In other cases they are widely torn, and the contraction of the quadriceps muscle separates the fragments by three or four inches, and sometimes causes tilting of the upper fragment. As the periosteum is usually torn at a level lower than the fracture, its free ends hang as a fringe from the upper fragment, and by getting between the broken ends may form a barrier to firm osseous union (Macewen). As the lower fragment is usually tilted forwards, it is often difficult to adjust the fragments accurately without an operation.

Clinical Features.—The limb is at once rendered useless, especially for movements of extension, the patient being unable to lift his heel off the bed. The knee-joint is filled with blood and effusion, which sometimes extends into the bursa under the quadriceps. The two fragments can be detected, separated by an interval which admits of the finger being placed between them, and this is increased on flexing the knee. On relaxing the quadriceps the fragments may be approximated more or less completely, and pain and crepitus elicited on rubbing them together. There is usually considerable ecchymosis on the sides and back of the knee.

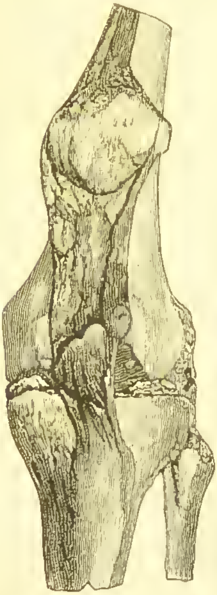

FIG. 161.—Fracture of Patella, showing wide separation of fragments, which are united by a fibrous band.

(Anatomical Museum of the University of Edinburgh.)

Prognosis.—In cases with little displacement, if the fragments be kept in perfect apposition osseous union may take place. In the great majority of cases, however, the union is fibrous. As time advances, the shortening of the quadriceps and the gradual stretching and thinning of the connecting fibrous band allow of wide separation of the fragments (Fig. 161), which to a variable extent interferes with the stability and functions of the limb. The upper fragment sometimes becomes attached to the front of the femur, and moves with it in extension, and the fibrous band between the two fragments gradually becomes stretched. With modern methods of treatment, complete restoration of function is usually attained within six or eight weeks. Previously the period of disability was often much longer. It is not uncommon for the patella to be refractured by a fall within a month or two of a previous fracture.

Treatment.—The best method of treating a fracture of the patella is still *sub judice.* It is probably true that the best functional results are most speedily obtained by operative measures. The laceration of the lateral aponeurosis, the tilting of the fragments, and the interposition of the torn periosteum between the fragments, can in no other way be rectified with certainty. The operation, however, should only be undertaken by those who are thoroughly familiar with wound technique, and who have every means at their disposal for carrying it out.

Operative Treatment.—Before performing the operation, the skin in the region of the knee must be carefully purified, the delay of one or two days thus entailed being, in our opinion, no disadvantage.

A vertical or semilunar incision, with its convexity upwards, is made through the skin and fascia, and the fragments freely exposed. All blood-clot is removed from the joint, the periosteum is reflected from between the fragments, and any clot or loose portions of bone lying between them removed. The fragments are then approximated by suturing the bone directly with silver wire, chromic gut, or fishing gut, after drilling holes obliquely to avoid piercing the articular cartilage. Where the fracture is comminuted, or the bone liable to be split up in the drilling process, the sutures may be applied circumferentially round the patella so as to draw the fragments into apposition. These sutures pass through the quadriceps tendon above and the ligamentum patellæ below, keeping as near to the bone as possible. Whichever method is adopted, the periosteum should be stitched over the fracture, and the tear in the aponeurosis closed with fine catgut sutures. Drainage is not necessary. The limb is fixed on a suitable splint.

So soon as the wound is healed—in a week or ten days—the splint may be removed, and massage and movement of the limb commenced, and the patient may be allowed to move his limb in bed. When silver wire sutures are used, he may be allowed up with sticks or crutches in a month after the operation, but when less rigid materials are used it is necessary to keep him in bed longer.

Subcutaneous operations are preferred by some; but as these measures are no safer than open operations, and are less certain, we prefer the latter.

Non-operative Treatment.—When there is no displacement, as in vertical fractures, or in transverse fractures not accompanied by laceration of the lateral expansions of the quadriceps tendon, the limb may be placed upon an inclined plane, to relax the quadriceps muscle, or in a Croft's or box splint extending well up the thigh. Massage should be carried out from the first, special care being taken, by moving it transversely, to prevent the patella forming adhesions with the front of the femur.

Wharton Hood recommends that the patient should be kept in bed for a day or two, the injured region being massaged daily. About the fourth day a strip of adhesive plaster, three inches wide, is applied so as to encircle the thigh in the lower third. The patient is then allowed to use the limb with caution. No attempt is made to approximate the fragments, as, according to Hood, fibrous union does not entail any interference with the utility of the limb.

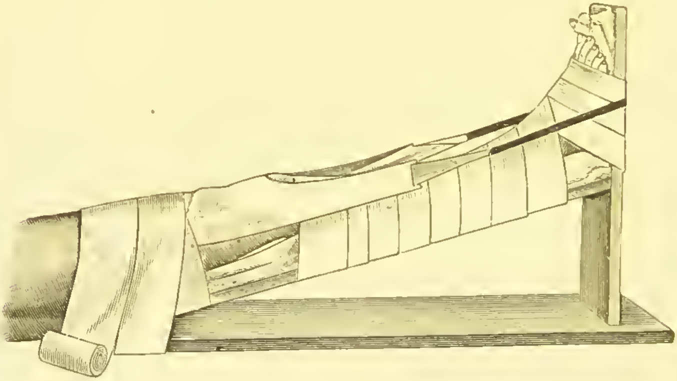

FIG. 162.—Treatment of Fracture of Patella by means of Inclined Plane and Elastic Extension.

The majority of surgeons, however, aim at bringing the fragments into apposition, and endeavour to secure osseous union if possible.

When the fragments are separated by more than three-quarters of an inch, and circumstances forbid operative treatment being adopted, the limb should be placed upon an inclined plane to relax the quadriceps muscle, and means taken to arrest effusion and to diminish the swelling of the joint by systematic massage and a supporting bandage. When, in the course of a few days, this has been accomplished, an attempt is made to approximate the fragments. This is done by fixing a large horse-shoe shaped piece of adhesive plaster to the front of the thigh, embracing the upper fragment. Extension is made upon this by means of rubber tubing, which is fixed to the foot piece of the splint (Fig. 162). The bandage which binds the limb to the splint should make upward pressure on the lower fragment, or this may be done by a special piece of adhesive plaster with elastic tubing pulling in an upward direction.

The retentive apparatus is kept on for about six weeks, and the knee must not be flexed lest the fibrous tissue be stretched. A rigid but easily removable apparatus is thereafter applied, and the patient allowed up on crutches, the limb being massaged daily to improve the tone of the muscles.

Old-standing Fractures.—When the usefulness of the limb is seriously impaired from want of union, or on account of the length of the fibrous band connecting the fragments (Fig. 161), it may be necessary to perform secondary suture. The operation is carried out on the same lines as that for recent fracture, the ends of the bones being rawed and adhesions divided. It is sometimes necessary to lengthen the quadriceps muscle by making a number of V-shaped incisions through its substance, before the fragments can be approximated.

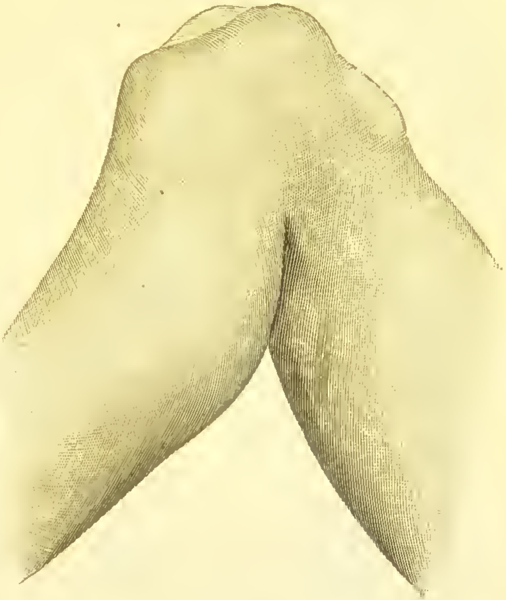

FIG. 163.—Old-standing Fracture of Patella with wide separation of fragments.

The patient was able to follow his occupation as a dock-labourer.

When operative treatment is contra-indicated, the patient should be fitted with a firm apparatus which will limit flexion of the knee and support the fragments.

Dislocations of the patella are rare. They result from exaggerated muscular movements when the limb is in the fully extended position, or from a blow on one or other edge of the bone. Laxity of the ligaments and knock-knee are predisposing factors.

The *outward* is the most common variety—the *inward* being very rare. Either may be complete or incomplete. Sometimes the bone is rotated so that its edge rests on the front of the femur—*vertical* dislocation (Fig. 164); and in a few cases it has been completely turned round, so that the articular surface is directed forwards.

Clinical Features.—The joint is fixed, usually in a position of slight flexion, and the displaced patella can readily be palpated. The deformity is a very striking one, and at first sight suggests a much more serious injury. Although easily reduced, the dislocation is liable to recur.

To effect reduction, the quadriceps must be thoroughly relaxed by extending the leg upon the thigh and flexing the thigh upon the pelvis. If the patella be now tilted by making firm pressure on that edge of it which lies furthest from the middle of the joint, and at the same time pushed towards the middle line, it usually slips into position without difficulty. The limb is placed on a posterior splint, and firm elastic pressure made on the joint to prevent or diminish effusion. Massage and movement are carried out from the first.

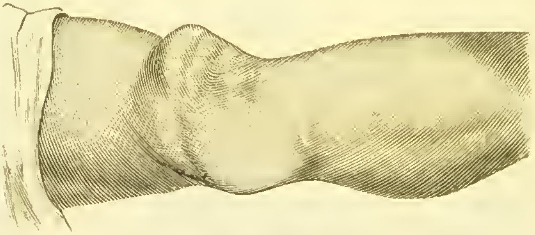

FIG. 164.—Vertical Dislocation of Patella.

As the displacement is liable to recur, the patient should wear a firm elastic bandage or a strong knee-cap.

Permanent and recurrent dislocations of the patella will be described in the chapter on deformities.

FRACTURES OF THE BONES OF THE LEG.

The bones of the leg may be broken together or separately.

Fracture of both Bones.—The nature of the violence producing this injury plays an important part in determining its anatomical and clinical features. Fracture by *direct* violence, such as the passage of a wheel over the limb, or a severe blow, may occur at any level, the bones giving way at the point of impact. The line of fracture tends to be transverse, both bones being broken at the same level (Fig. 165). There is often little or no displacement, and such as there is is angular, and is determined by the direction of the fracturing force.

When the violence is *indirect*, as from a fall on the feet, or a twist of the foot, the tibia usually gives way at the junction of its lower and middle thirds, and the fibula at a higher level (Fig. 166). Torsion of the leg is probably the most important factor in the production of the fracture, the lower fragment being fixed by the pressure of the foot upon the ground, while the upper fragment is rotated by the impetus of the body. Both fractures are usually oblique—that in the tibia running from above downward, forward, and inward, and it is generally found that the obliquity of the fibular fracture corresponds with that in the tibia.

Muscular contraction alone may produce fracture of both bones, or may augment the twisting force.

There is usually considerable displacement. The upper fragments project forwards, while the lower fragments tend to move backwards under the influence of gravity and the traction of the calf muscles. The calf muscles pull up the heel and point the toes, and the weight of the foot causes it to fall outwards.

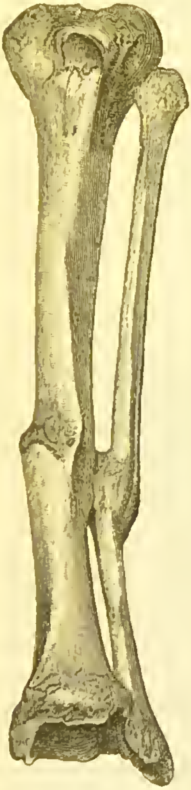
Fig. 165.—Transverse Fracture of both Bones of Leg by direct violence.

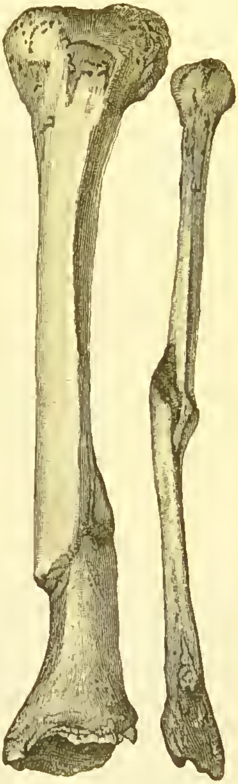
Fig. 166. — Oblique Fracture of both Bones of Leg by indirect violence.

On account of the superficial position of the tibia and the pointed character of the fragments, this fracture is frequently rendered compound by the bone coming through the skin. The projecting piece of bone is usually the lower end of the upper fragment. This fracture is also very often comminuted. It has been observed that when the line of fracture forms the letter V on the subcutaneous surface of the tibia, there is invariably a fissure passing along the back of the bone into the ankle-joint—a complication which adds to the risk of subsequent stiffness and impaired usefulness of the limb. We have frequently found the superior tibio-fibular articulation torn open in severe fractures of both bones of the leg.

Clinical Features.—The tibial fracture is always readily recognised by running the fingers along the crest of the shin, an irregularity being detected. Abnormal mobility, tenderness, and crepitus are usually to be elicited at this point. It is often difficult to make out the fibular fracture, and it is not always advisable to attempt to do so, especially if the manipulations cause pain or tend to increase the displacement. Not infrequently it may be recognised by detecting a point of maximum tenderness at the seat of fracture, or of pain on distal pressure. The condition of the fibula can usually be inferred by noting the amount of deformity, and the extent of mobility of the tibial fragments.

On account of the close connection of the skin to the periosteum on the subcutaneous aspect of the tibia, the tension caused by extravasated blood is often extreme and blisters frequently form over the area of ecchymosis. When infected by bacteria these are liable to lead to sloughing of the skin, which may render the fracture compound.

The vessels and nerves of the leg are seldom damaged.

Simple fractures without displacement usually consolidate in from four to six weeks. When oblique, comminuted or compound union is often delayed, and the functions of the limb may not be regained until three or even four months after the accident.

Treatment.—Reduction of the fracture is best accomplished under anæsthesia. Traction is made upon the foot while the fragments are manipulated into position. The pointing of the toes and the outward rotation of the foot have at the same time to be corrected. The normal outline of the leg is restored when the ball of the great toe, the internal malleolus, and the inner edge of the patella are in the same plane.

The retentive apparatus to be applied depends upon the tendency to redisplacement, the degree of swelling, and the extent of the damage to the skin.

In transverse fractures with a moderate amount of swelling, and intact skin, the limb may immediately be enclosed in a rigid apparatus such as lateral poroplastic splints retained in position by an elastic bandage, or a plaster of Paris case, preferably in the form of a Croft's splint, which admits of massage being carried out from the first. When the fracture is in the lower third of the leg the ambulatory splint (Fig. 171) gives excellent results, and is of special service in hospital practice. This splint allows of a certain amount of movement of the muscles, and it is usually found when it is removed at the end of three or four weeks that the ankle is freely movable and there is no atrophy of muscles.

When the fracture is oblique and it is difficult to retain the fragments in position, or when there is great swelling with bullæ or bruises on the skin, a splint which can easily be taken off and replaced is to be preferred. One of the simplest and most efficient is the Box Splint (Fig. 168). This consists of two pieces of wood extending from above the knee to an inch or two beyond the sole, and a little broader than the maximum diameter of the leg. These are rolled into the opposite ends of a folded sheet so as to form two sides of a box, of which the sheet constitutes a third side. It is often found advantageous to insert another board, fitted with a foot-piece, between the folds of the sheet forming the third side of the box, to add to the rigidity of the splint, and to aid in controlling the foot. By folding one side of the sheet somewhat obliquely, the box is made a little wider at the knee than at the ankle, and so fits the limb more accurately.

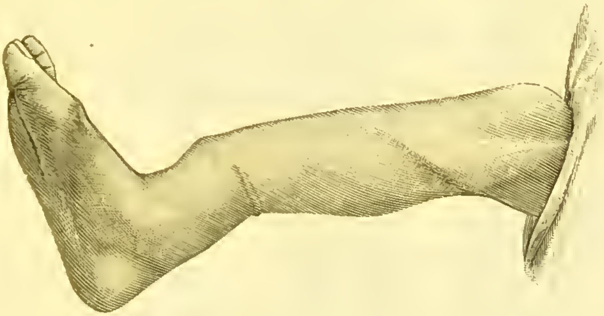

FIG. 167.—Recent Fracture of both Bones of Leg in Lower Third by direct violence.

The limb is placed in this box, the sides of which have been carefully padded. Pressure is taken off the condyles, the head of the fibula, the malleoli and the tip of the heel by ring pads, and a large supporting pad is placed behind the tendo Achillis. A folded towel is laid over the front of the leg, forming a lid to the box, and the whole is bound to the limb by three slip knots. Finally the foot is fixed at right angles to the leg by a figure-of-eight bandage or a piece of elastic webbing. Sandbags placed alongside serve to steady the limb. When the box splint stops short of the knee the limb may be suspended in a Salter's cradle, which allows the patient to move about more freely in bed.

To prevent shortening in oblique fractures and in those near the ankle-joint, where it is often difficult to control the lower fragment, extension, applied by weight and pulley, may be of service. The strapping may be applied only to the lower fragment, but we prefer to carry it to the upper third of the leg.

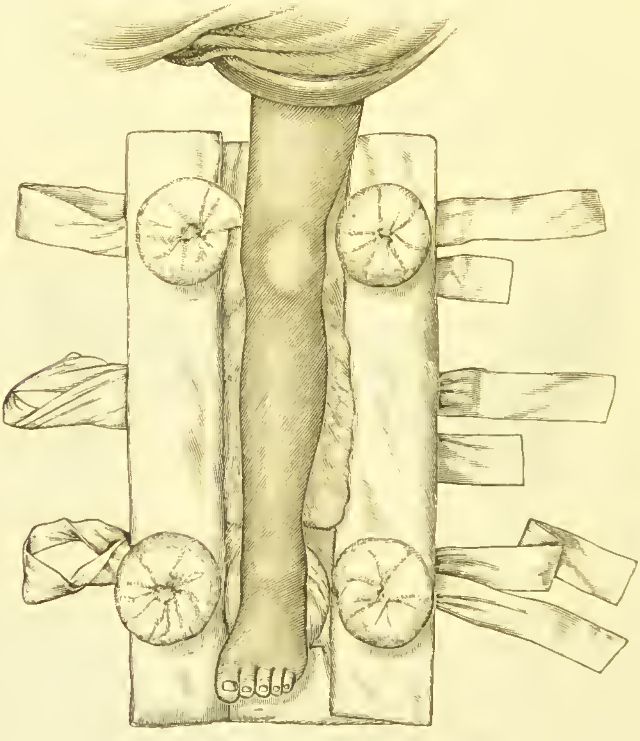

FIG. 168.—Box Splint for Fractures of Bones of Leg.

When the skin is damaged, as it so frequently is on the inner aspect of the tibia, antiseptic and protective dressings must be applied to prevent septic infection, and to promote healing.

Massage is carried out daily so soon as the condition of the skin will admit of it, and to prevent stiffness the ankle is moved from the commencement of treatment. In the course of three weeks, when the fracture is consolidated, lateral poroplastic splints, retained by an elastic bandage, may be substituted, and the patient allowed up on crutches. Union is usually complete in from six to eight weeks.

Operative Treatment.—When overriding cannot otherwise be corrected it is advisable to secure the fracture mechanically by operation. A curved incision with its convexity backward is made over the inner side of the tibia, exposing the fragments which are then screwed, pegged, or wired according to circumstances. It is seldom necessary to deal specially with the fibula. A box splint is applied till the wound has healed, after which a Croft's splint is substituted and massage commenced.

We do not share in the dissatisfaction expressed by some surgeons, notably Arbuthnot Lane, as to the results obtained by non-operative means in these fractures, and do not recommend a systematic resort to operative treatment.

Ununited fracture of the bones of the leg is sometimes met with. It is treated on the same lines as in other situations, but may prove extremely intractable, especially in the case of children, in whom indeed it is sometimes incurable.

Mal-union, on account of the disability it entails, may call for operative treatment in the form of osteotomy of one or both bones.

Compound fractures are treated on the lines already laid down for the treatment of compound fractures in general.

Fracture of the tibia alone is due to direct violence or to a twist of the foot. There is little displacement, as the intact fibula retains the fragments in position, and union takes place rapidly and without deformity.

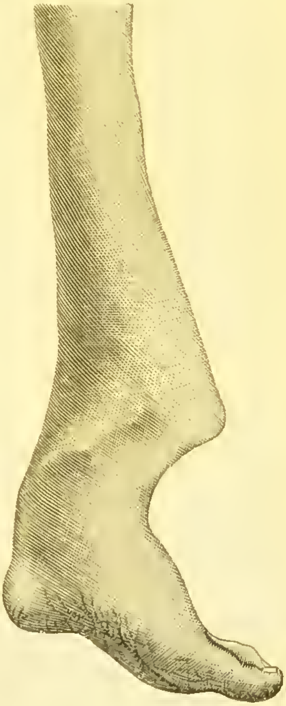

FIG. 169. — Badly - united Fracture of both Bones of Leg.

Fracture of the fibula alone may result from direct violence, and, on account of the support given by the tibia, is usually unattended by displacement or deformity. Bennett of Dublin has pointed out that it is common to meet with an oblique fracture of the upper third of the fibula as the result of an outward twist of the ankle while the foot is extended. This fracture is characterised by pain localised at the seat of the break, on moving the foot in such a way as to bring the astragalus to bear against the fibula. Local pressure also may make the fibula yield and may elicit crepitus. In some cases this fracture is associated with injuries in the region of the ankle-joint. This fracture is very often overlooked, and from want of proper treatment results in prolonged impairment of usefulness of the limb.

Treatment.—Fractures of the tibia or fibula alone are treated on the same lines as fractures of both bones. The ambulant method of treatment is particularly useful in these cases (Fig. 171).

CHAPTER XXVII.

INJURIES IN REGION OF ANKLE AND FOOT.

Surgical anatomy—FRACTURES: *Pott's fracture; Converse of Pott's fracture; Separation of lower epiphysis; Fracture of astragalus; Fracture of os calcis; Fractures of other tarsal bones; Fractures of metatarsal bones; Fractures of phalanges*—DISLOCATIONS: *Of ankle-joint; Of inferior tibio-fibular joint; Complete dislocation of astragalus; Sub-astragaloid dislocation; Medio-tarsal dislocation; Tarso-metatarsal dislocation; Dislocations of toes.*

THE fractures in this region include Pott's fracture, and its converse; separation of the lower epiphysis of the tibia; fractures of the astragalus, os calcis, and other tarsal bones; and fractures of the metatarsals and phalanges. Various dislocations also occur, the most important being those of the ankle-joint, of the astragalus, and the sub-astragaloid dislocation.

Surgical Anatomy.—In studying the injuries in the region of the ankle-joint it is of importance to understand the terms which are employed in describing the movements of the foot. Thus by *flexion* or *dorsi-flexion* is meant that movement which approximates the dorsum of the foot to the front of the leg; while *extension* or *plantar flexion* means the drawing up of the heel so that the toes are pointed. In *inversion* the inner edge of the foot is drawn up so that the sole looks inwards, an attitude which is analogous to supination of the hand. In *eversion* the outer edge of the foot is drawn up, the sole looking outwards—analogous to pronation of the hand. *Adduction* indicates the rotation of the foot so that the toes are turned towards the middle line; while in *abduction* the toes are turned away from the middle line.

The most prominent bony landmarks in the region of the ankle are the two *malleoli*, the external lying further back, and about half an inch lower than the internal. On the inner side of the foot from behind forward may be felt the *internal tuberosity* of the os calcis, the *sustentaculum tali*, which lies about one inch vertically below the tip of the malleolus, the *tubercle of the scaphoid*, about an inch in front of the malleolus, and at a slightly lower level; the *internal cuneiform*, and the base, shaft, and head of the *first metatarsal.*

On the outer side may be recognised the *external tuberosity* of the os calcis, the *peroneal tubercle* on the same bone; the *cuboid;* and the prominent base of the *fifth metatarsal.*

The astragalo-scaphoid joint lies immediately behind the tubercle of the scaphoid, and a line drawn straight across the foot at this level passes over the calcaneo-cuboid joint.

The *ankle-joint,* formed by the articulation of the tibia and fibula with the astragalus, lies about half an inch above the tip of the internal malleolus, and is so constructed that when the foot is at a right angle with the leg, it is only possible to flex and extend the joint. When the toes are pointed, however, slight lateral and rotatory movements are possible. The chief seat of lateral movement of the foot is at the astragalo-scaphoid and calcaneo-cuboid articulations—"the mid-tarsal joint."

The ankle-joint owes its strength chiefly to the malleoli and the external and internal lateral ligaments, and to the inferior tibio-fibular ligaments, which bind together the lower ends of the bones of the leg. The numerous tendons passing over the joint on every side also add to its stability.

The synovial membrane of the ankle-joint passes up between the bones of the leg to line the inferior tibio-fibular joint; but it is distinct from that of the inter-tarsal joints, which communicate with one another in a complicated manner.

FRACTURES IN THE REGION OF THE ANKLE.

Pott's Fracture.—It must clearly be understood that various lesions occurring in the region of the ankle-joint are included under the clinical term "Pott's fracture." Although of a similar nature, and produced by similar forms of violence, they vary considerably in their anatomy and clinical features. They are all the result of *combined eversion and abduction* of the foot—produced, for example, by the foot slipping off the kerb-stone, or by the patient jumping from a height and landing on the inner side of the foot.

When forcible *eversion* is the chief movement, the tightening of the internal lateral ligament usually tears off the internal malleolus across its base. The astragalus is then brought to bear on the external malleolus, and the inferior tibio-fibular ligament may rupture, or the outer portion of the tibia to which it is attached may be avulsed. This form is sometimes called *Dupuytren's fracture.* The force continuing to act, the lower end of the fibula is pressed outwards and breaks close above the malleolus. When the bones are widely separated in Dupuytren's fracture the astragalus may be forced up between them, causing great broadening of the ankle.

When the movement of *abduction* predominates, the internal lateral ligament is usually ruptured, or the anterior edge or tip of the malleolus torn off. The inferior tibio-fibular ligament usually resists, and an oblique fracture of the fibula three or four inches from its lower end results.

Clinical Features.—In a considerable proportion of cases—in our experience in the majority—this fracture is not accompanied by any marked deformity of the foot, and the patient is often able to walk after the injury with only a slight limp.

In others, however, the deformity is marked and characteristic (Fig. 170). The foot is everted, its inner side resting on the ground. The internal malleolus is unduly prominent, stretching the skin, which may give way if the patient attempt to walk. The foot having lost the support of the malleoli, is often displaced backward, and the toes are pointed by the contraction of the calf muscles. There is abnormal mobility—both lateral and antero-posterior—and crepitus may be elicited. The points of tenderness are over the internal lateral ligament or internal malleolus, according to which is damaged; the inferior tibio-fibular joint, and at the seat of fracture of the fibula. Distal pressure over the shaft of the fibula, or on the extreme tip of the malleolus, may also elicit pain and crepitus at the seat of fracture. There is usually considerable ecchymosis and swelling in the hollows below the malleoli. In Dupuytren's fracture, when the astragalus passes up between the tibia and fibula, there is great broadening of the ankle.

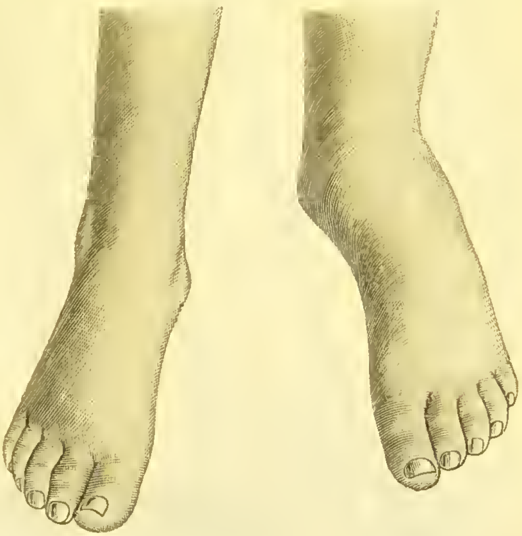

FIG. 170.—Pott's Fracture with marked deformity.

There is often great difficulty in distinguishing a fracture without displacement in the region of the ankle-joint from a *sprain.* Both forms of injury result from the same kinds of violence, and are rapidly followed by marked swelling and discoloration of the overlying soft parts. When a sprain is accompanied by effusion into the ankle-joint there is a distinct tender swelling in front of the articulation, especially marked towards the outer side of the extensor tendons, and the hollow on each side of the tendo Achillis is filled up by a similar swelling. Pain is caused by pressing the articular surfaces against one another. The sheaths of the tendons passing over the joint are often distended with fluid and yield a peculiar crepitant creaking when the foot is moved. In a sprain the point of maximum tenderness is over the ligaments which have been damaged, whereas in fracture the site of the break is the most tender spot. The X-rays are often useful in doubtful cases.

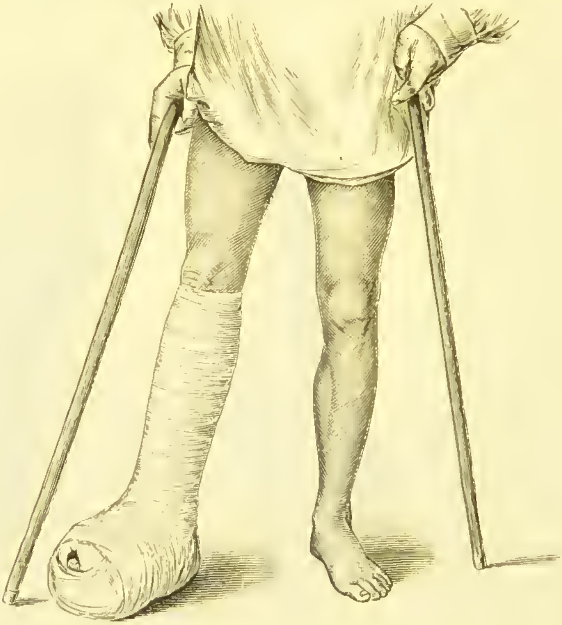

Fig. 171.—Ambulant Splint of Plaster of Paris.

When any doubt remains as to the diagnosis, the injury should be treated as a fracture.

Treatment.—In those cases of fracture of the lower end of the fibula in which there is no marked displacement—and they constitute a considerable proportion—the limb should be massaged and laid on a pillow between sandbags, or placed in a box splint for two or three days, until the swelling subsides, after which some form of rigid, moulded splint is applied, which will allow the patient to get about with crutches. A useful appliance for this purpose is lateral poroplastic splints fixed in position with an elastic bandage, which has the advantage over a plaster of Paris case, that it can be removed daily to permit of massage and movement being carried out. This is a point of great practical importance, because if massage and movement be neglected not only does union take place more slowly, but the persistent stiffness of the ankle and œdema of the leg and foot which ensue prolong the period of the patient's incapacity, and endanger the functional usefulness of the limb.

It is in cases of this kind that the *ambulatory method* of treatment yields its best results. When, in the course of two or three days, the swelling has subsided, a plaster of Paris case (Fig. 171) is applied in such a way that when the patient walks the weight is transmitted from the tuberosities of the tibia through the plaster case to the ground, no weight being borne by the bones at the seat of fracture. This is done as follows:—A boracic lint bandage is applied to the limb as far as the knee, and protecting pads or rings of wool are placed over the tuberosities of the tibia, the head of the fibula, and the malleoli. A pad of wool about three inches thick is then placed under the sole of the foot and fixed in position by a plaster of Paris bandage, which is carried up the limb in the usual way. The case is made specially strong on the sole, around the ankle, along the sides of the leg, and at the bearing-point at the head of the tibia. After the plaster has thoroughly set, the patient is allowed to walk about with a stick, crutches being unnecessary. In the course of three weeks the plaster case may be removed and the limb massaged. It is usually found that the movements of the ankle are scarcely interfered with, and the patient is generally able to resume work within a month of the accident.

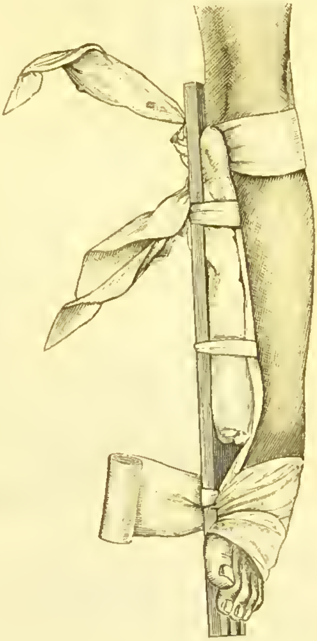

Fig. 172.—Dupuytren's Splint applied to correct eversion of foot.

When there is marked eversion of the foot it is sometimes necessary to reduce the deformity under chloroform, and if it tends to recur this may be prevented by *Dupuytren's splint* (Fig. 172). This splint, which is the same shape as Liston's long-splint, but on a smaller scale, is applied to the inner side of the leg, extending from the internal tuberosity of the tibia to well beyond the sole of the foot. A large pad is placed in the hollow above the internal malleolus, and must be thick enough to carry the splint so far from the limb that when the foot is fully inverted it does not touch the splint. The upper end of the splint having been fixed to the leg, a bandage is applied to correct the eversion of the foot, and at the same time to support the heel, and, as far as possible, to overcome the pointing of the toes. Care must be taken to avoid carrying the turns of this bandage over the seat of fracture. The limb may then be slung in a cradle, or placed on a pillow resting on its outer side with the knee flexed. In the course of a week or ten days a poroplastic or a Croft's splint may be substituted, and massage commenced.

When backward displacement of the heel is the prominent deformity, *Syme's horse-shoe splint* (Fig. 173) may be found useful. It is applied to the anterior aspect of the limb, which is carefully padded to prevent undue pressure on the edge of the shin bone. In order that the splint may have a flat surface to rest upon, the padding must be twice as thick over the inner as over the outer side of the leg. After the upper end of the splint has been fixed below the knee, the heel is pulled forward by a few turns of bandage passed over the prongs at the lower end of the splint. The foot is then inverted and brought up to a right angle by a few supplementary turns of the bandage. In a week or ten days this appliance may be replaced by a poroplastic or a Croft's splint.

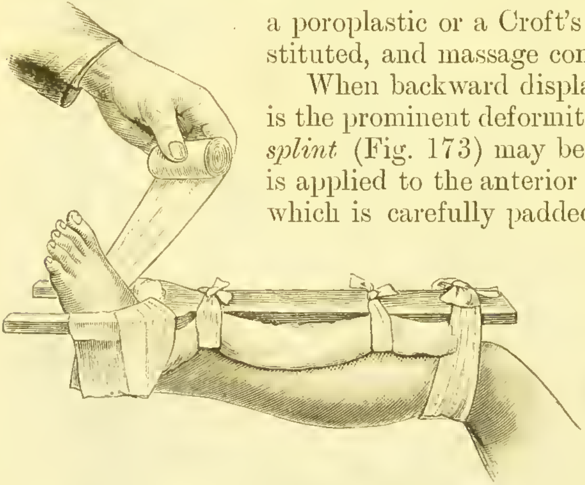

FIG. 173.—Syme's Horse-shoe Splint applied to correct backward displacement of foot.

Mal-union of Pott's fracture may necessitate an operation to restore the usefulness of the ankle. This consists in dividing the bone by means of an osteotome, forcibly inverting the foot, and then putting the limb up in the same way as a recent fracture.

The Converse of Pott's Fracture — sometimes called "Pott's Fracture with Inversion." — This injury is fairly common and results from forcible inversion of the foot. The external malleolus is broken across its base, or, in young subjects, along the epiphysial line. The internal malleolus alone may be carried away, or a portion of the broad part of the tibia may accompany it.

The foot is inverted, the heel falls back, and the toes are pointed (Fig. 174).

In other respects it corresponds to the typical Pott's fracture, and is treated on the same principles. When Dupuytren's splint is required it is, of course, applied to the outer side of the leg.

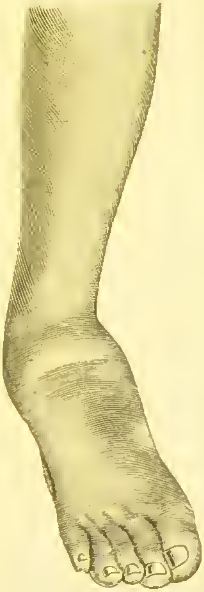

FIG. 174. — Converse of Pott's Fracture. Man aet. 37. Blow on outer side of ankle. Tibia broken about two inches above top of internal malleolus. Tip of external malleolus chipped off.

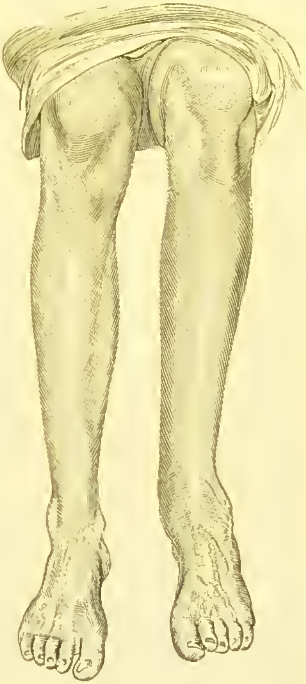

FIG. 175.—Partial Separation of Lower Epiphysis of Tibia, in a boy aet. 16.

Separation of the *lower epiphysis of the tibia* is not very common. It occurs most frequently between the age of eleven and eighteen as a result of forcible eversion or inversion of the foot. It is usually accompanied by fracture of the diaphysis of the fibula, and is not infrequently compound. When displaced outward or inward, the deformity is very characteristic. The growth of the tibia may be arrested, in which case the continued growth of the fibula causes the foot to become inverted. The treatment is the same as for Pott's fracture.

Fracture of the astragalus may occur as a result of a fall from a height, the bone being crushed between the tibia and the os calcis. It is usually associated with other fractures, and its diagnosis is only to be made by exclusion, or by the use of the Röntgen rays. In interpreting radiograms of injuries in this region, care must be taken not to mistake the os trigonum tarsi for a fracture. The only satisfactory treatment is complete excision of the bone—an operation which usually yields very good results.

The **os calcis** is usually broken by a fall from a height, landing on the sole of the foot. Forcible contraction of the calf muscles may tear off the portion of the bone to which the tendo Achillis is attached.

When the result of a fall on the foot the primary fracture is usually longitudinal, passing through the facets for the astragalus and cuboid, and from this various secondary fissures radiate, and the cancelled tissue is much crushed, so that the whole bone is flattened out. In spite of the great comminution of the bone it is often impossible to elicit crepitus, as the fragments are held together by the investing soft parts. In other cases the foot may feel like "a bag of bones." The lesion is often mistaken for a fracture of the lower end of the fibula, or is not diagnosed at all. The chief clinical feature is pain on movement of the foot, or on attempting to walk. The foot appears flat, and the hollows on either side of the tendo Achillis are filled up. In many cases there is a persistent tenderness in the foot which delays restoration of function. The injury may occur simultaneously in both feet.

Separation of the posterior tubercle by forcible contraction of the tendo Achillis may result from a misstep, or from a fall on the ball of the foot. The separated fragment is pulled up for a distance of one or two inches, and the rough surface from which it has been torn may be recognised. The patient is often able to walk immediately after the accident, although with difficulty.

Treatment.—In simple comminuted fractures the patient should be anæsthetised, and the foot moulded into position, special care being taken to restore the arch in order to avoid any tendency to flat foot. A plaster of Paris case or Croft's splint is then applied, and the foot suspended in a cradle to relax the calf muscles. Massage and movements of the ankle and tarsal joints should be commenced within a few days to prevent stiffness.

Compound fractures confined to the os calcis may be treated on conservative lines, but if associated with other injuries of the foot may necessitate amputation.

When the posterior part of the bone is torn off by the tendo Achillis, a good functional result is usually obtained by relaxing the calf muscle and fixing the foot in the position of extreme plantar flexion with the knee flexed, but in some cases it may be advisable to peg the fragments, either through the skin or after exposing them by incision.

The *other bones of the tarsus* are very rarely fractured separately.

Fractures of the metatarsals and phalanges usually result from direct violence, crushing the foot and severely damaging the soft parts.

When simple, these injuries are often overlooked on account of the difficulty of eliciting the signs of fracture, owing to the swelling which accompanies them. The use of the Röntgen rays has shown that certain painful conditions in the foot following comparatively slight injuries are due to undetected fractures of metatarsals or phalanges. These injuries are best treated in a rigid moulded splint.

Compound fractures are more commonly met with, and are to be treated on the same principles as govern such injuries elsewhere.

A fracture of the base of the fifth metatarsal has been described by Jones of Liverpool. It is produced by the patient coming down forcibly on the outer edge of the foot while the foot is inverted and the heel raised—as, for example, in dancing. There is a localised swelling over the base of the fifth metatarsal, and pain when the patient puts weight on the foot. There is no crepitus or deformity. The fracture is readily recognised by the Röntgen rays. It is treated by massage and movement.

Dislocations in the Region of the Ankle.

Dislocations of the Ankle-joint.—In describing dislocations of the astragalus from the tibio-fibular socket, the varieties are named according to the direction in which the foot passes—backward, forward, inward, outward, or upward.

All of them may be complete, but are more frequently incomplete, and they are all liable to become compound, either from tearing of the skin at the time of the injury, or by its sloughing at a later period. Although as a rule there is little difficulty in effecting reduction by manipulation, these injuries are liable to be followed by stiffness and impaired usefulness of the joint.

The *backward* dislocation is the most common, and results from extreme plantar flexion of the foot, wedging the astragalus between the tibia and fibula, as from a fall backwards while the foot is fixed. The lateral ligaments are torn, and one or both malleoli may be broken, or the posterior part of the articular edge of the tibia chipped off.

The foot appears shortened, the heel is unduly prominent behind, and the lower ends of the tibia and fibula project in front, sometimes coming through the skin. The tendons around the joint are stretched or torn.

Forward dislocation results from extreme dorsal flexion of the ankle-joint. The foot appears lengthened, the heel is less prominent than normal, and the hollows on each side of the tendo Achillis are obliterated. The astragalus is felt in front of the tibia, and the malleoli appear to be displaced backwards and towards the sole.

Lateral dislocations—inward or outward—are only possible after fracture of one or both malleoli, and may be looked upon as complications of these injuries.

The astragalus may pass *upwards* between the bones of the leg in cases where the interosseous ligament is ruptured, and in aggravated cases of Dupuytren's fracture. There is great broadening in the region of the ankle, and the malleoli are unduly prominent under the skin, which is tightly stretched over them. They are also nearer to the sole than normal. The movements of the ankle-joint are lost.

Dislocation of the *inferior tibio-fibular joint* is exceedingly rare, except in association with fractures of the lower ends of the bones of the leg, particularly Dupuytren's fracture, or with dislocation of the ankle-joint proper.

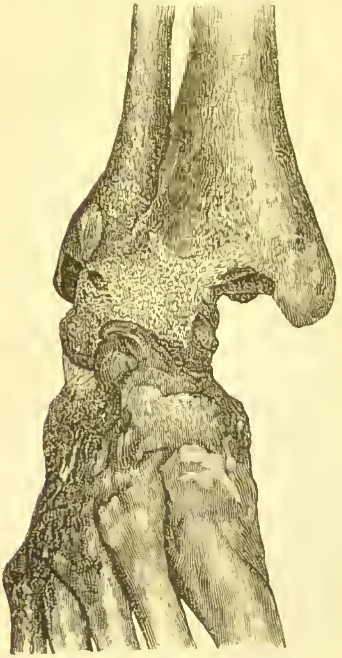

FIG. 176.—Ankylosis of Ankle after Compound Fracture with Lateral Dislocation of Ankle.

(Specimen in Professor Annandale's collection.)

Treatment.—The patient having been anæsthetised, the foot is extended and the knee and hip joints flexed in order to relax the calf muscles as completely as possible. Traction is then made upon the foot, while counter-extension is applied to the leg, and the bones are manipulated into position. Reduction usually takes place gradually without the characteristic snap which accompanies reduction of most dislocations. It is sometimes necessary to divide the tendo Achillis, particularly in cases of forward dislocation.

When the astragalus passes upwards between the tibia and fibula, it is sometimes impossible to effect reduction by manipulation, and the best results are then obtained by excising the astragalus.

The after treatment of dislocations of the ankle consists in applying massage to the foot and ankle, and keeping the leg on a pillow between sandbags. After all swelling has been dispersed, a splint is applied to prevent backward displacement of the heel.

In compound dislocations which have become infected primary amputation may be indicated, but in young and healthy subjects an attempt should be made to save the foot.

Dislocation of the astragalus from its articulations with the bones of the leg above and the os calcis and scaphoid below, is a comparatively common injury, and results from a violent wrench of the foot. It may be incomplete or complete When the foot is plantar-flexed at the moment of injury the displacement is generally *forward* with a tendency outward. The astragalus comes to rest on the external cuneiform and cuboid bones, the foot being adducted, inverted, and displaced bodily inward. In a large proportion of cases the dislocation is compound, more or less of the astragalus being forced through the skin of the dorsum of the foot (Fig. 177).

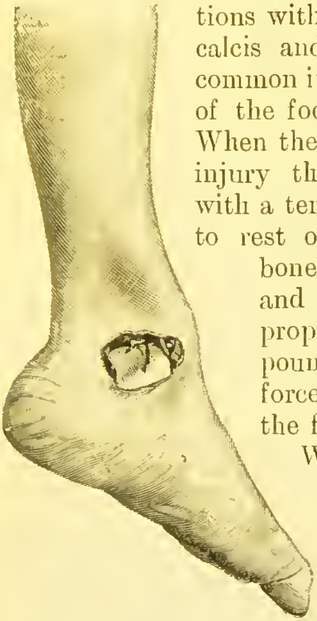

Fig. 177.—Compound Dislocation of the Astragalus.

(Dr. Wm. Stewart's case.)

When the foot is dorsi-flexed at the moment of injury the displacement is *backward*, but this is very rare, as are also *lateral dislocations*, and *dislocation by rotation*, in which the astragalus is rotated in its socket. In all these injuries the head of the astragalus loses its normal relationship with the malleoli.

Treatment.—An attempt should be made to reduce the dislocation under anæsthesia, the limb being placed in the same position as for reduction of dislocations of the ankle. While traction is made upon the foot, an assistant presses directly on the displaced bone and endeavours to manipulate it into position. This usually succeeds in incomplete dislocations, but it not infrequently fails in those which are complete, and in this case it is best to excise the astragalus. In most cases of compound dislocations also the bone should be removed. The after treatment is carried out on the same lines as for dislocations of the ankle.

Sub-astragaloid Dislocation.—In this dislocation, which results from the same kinds of violence as the last, the astragalus retains its position in the tibio-fibular socket, and the os calcis and scaphoid, with the rest of the foot, are carried away from it. The head of the astragalus, therefore, maintains its normal relationship with the malleoli—a point of importance in the differential diagnosis between this injury and dislocation of the astragalus. The displacement is usually incomplete, and the foot may either pass backward and inward, or backward and outward. When the foot passes *backward and inward*, the head of the astragalus projects on the outer part of the dorsum, resting on the cuboid. The dorsum of the foot is shortened, the heel lengthened, the toes adducted, and the inner border of the foot raised. The external malleolus is unduly prominent, and reaches nearly to the sole.

In the *backward and outward* variety, the internal malleolus and head of the astragalus project unduly towards the inner side of the foot, which is abducted and everted.

In neither variety is there any mechanical obstacle to movement at the ankle-joint.

The *treatment* is carried out on the same lines as for dislocation of the astragalus, reduction being effected without difficulty in most cases. If this fails, as it occasionally does, it may be necessary to excise the astragalus.

Medio-tarsal dislocation—that is, at the astragalo-scaphoid and calcaneo-cuboid articulations — is extremely rare. The distal segment of the foot is usually displaced towards the sole; the foot is foreshortened, the malleoli raised from the sole, the arch of the foot is lost, and the first row of tarsal bones project on the dorsum. The treatment consists in reducing the displacement by manipulation, after which massage and movement are employed.

Tarso-metatarsal Dislocations.—One, several, or all of the metatarsals may be separated from the distal row of tarsal bones —the usual cause being a fall from a horse, the foot being fixed in the stirrup. The bases of the metatarsal bones are displaced outward and toward the dorsum. Reduction by manipulation is generally easy.

Dislocations of the Toes.—The great toe may be dislocated at its metatarso-phalangeal joint, the base of the proximal phalanx passing outward and towards the dorsum. Diagnosis and reduction are alike easy. Inter-phalangeal dislocations are very rare.

CHAPTER XXVIII.

DISEASES OF BONE.

Anatomy and physiology — Regeneration of bone — Transplantation of bone. DISEASES OF BONE—Definition of terms—Pyogenic diseases: *Acute osteomyelitis and periostitis; Chronic and relapsing osteomyelitis; Abscess of bone*—Tuberculous diseases—Syphilitic diseases—Hydatids; Rickets; Osteomalacia—Tumours of bone.

Surgical Anatomy.—During the period of growth a long bone, such as the tibia, consists of a shaft or *diaphysis*, and two extremities or *epiphyses*. So long as growth continues there intervenes between the shaft and each of the epiphyses a disc of actively growing cartilage—*the epiphysial cartilage.* At the junction of this cartilage with the shaft is a zone of young, vascular, spongy bone known as the ossifying or *epiphysial junction.* The shaft may be described as a cylinder of compact bone—the cortex—enclosing the medullary canal, which is filled with marrow. The extremities, which include the ossifying junctions, consist of spongy bone, the spaces of which are also filled with marrow. The articular aspect of the epiphysis is invested with a thick layer of hyaline cartilage, known as the articular cartilage.

The external investment of the bone—the *periosteum*—is thick and vascular during the period of growth, but becomes thin and less vascular when the skeleton has attained maturity. It is easily detached from the shaft of the bone except at the attachments of muscles; at the extremities it is intimately connected with the epiphysial cartilage and with the epiphysis, and at the margin of the latter it becomes continuous with the capsular ligament of the adjacent joint.

The arrangement of the blood-vessels determines to some extent the incidence of certain of the diseases to which bones are liable. The nutrient artery, after entering the medullary canal through a special foramen in the cortex, bifurcates, and one main division runs towards each of the extremities of the bone, and terminates at the ossifying junction in a series of capillary loops projected against the epiphysial cartilage. This arrangement of capillary loops favours the lodgment of any organisms which may be circulating in the blood, and is partly accountable for the frequency with which diseases of bacterial origin develop in the region of the ossifying junction. The shaft of the bone is nourished also by numerous blood-vessels from the periosteum, which penetrate the cortex through the Haversian canals and anastomose with those derived from the nutrient artery.

The epiphyses are nourished by a separate system of blood-vessels, chiefly derived from the arteries which supply the adjacent joint. The veins of the marrow are remarkable for their large calibre and for the absence of valves. The nerves enter the marrow along with the arteries, and, being derived from the sympathetic system, are probably chiefly concerned with the innervation of the blood-vessels, but they are also capable of transmitting sensory impulses, as pain is a prominent feature of many bone affections.

Functions of the Periosteum, Marrow, and Epiphysial Cartilage.—The periosteum is devoted to the formation of new bone. The marrow, in addition to its blood-forming functions, is chiefly concerned in the absorption of bone which is in excess of physiological requirements. In diseased conditions the formation of new bone by the periosteum may be arrested, retarded, or exaggerated. In paralysed limbs, and especially in children, the function of the periosteum is often in abeyance, and the bones are abnormally thin and smooth. Increase in the activity of the periosteum results in an addition to the thickness or to the girth of the affected bone. When the new bone is added in the shape of a uniform layer on the surface, the condition is spoken of as *hyperostosis;* when it assumes the form of spicules or irregular outgrowths, these are spoken of as *osteophytes;* and when it is heaped up so as to form a circumscribed elevation, this is described as a *node.*

Under certain conditions—and especially from the prolonged irritation caused by pyogenic infection or by syphilis—the marrow may assume active bone-forming functions. This may lead to condensation of the spongy bone, and to diminution or obliteration of the medullary canal, whereby the bone becomes dense and heavy; to this condition the name *sclerosis* is applied. When the periosteum and marrow are simultaneously engaged in the excessive formation of new bone, a combination of hyperostosis and sclerosis results.

Under other conditions the absorption of lime salts and excavation of bone may be excessive, and the shaft, which was originally firm and rigid, may become soft and brittle. These changes may render the bone liable to break under slight violence, or to bend under the weight of the body.

The term *hypertrophy of bone* refers to a physiological increase in the bone-forming functions of the periosteum or of the marrow, or of both combined; the term *atrophy* to a condition in which the formation of bone is retarded or arrested, or in which the absorption of bone is in excess of the normal. There is both diminished formation and excessive absorption of bone in the atrophy which accompanies old age. Considerable interest attaches to that form met with in the neck of the femur, in which, while the bone retains its external form, there is excavation and enlargement of the marrow spaces at the expense of the osseous framework; this is sometimes described as eccentric atrophy or senile *osteoporosis.*

The function of *the epiphysial cartilage* is to provide for the growth of the shaft in length. While all epiphysial cartilages contribute to this result, certain of them functionate more actively and for a longer period than others. Those at the knee contribute more to the length of the lower limb than do those at the hip or ankle, and they are also the last to unite. In the upper limb this arrangement is reversed, for the more active epiphyses are at the shoulder and wrist, and, like those at the knee, are also the last to unite.

The activity of the epiphysial cartilage may be modified as a result of disease. In rickets, for example, the formation of new bone may take place unequally, and may go on more rapidly in one half of the disc than in the other, with the result that the axis of the shaft comes to deviate from the normal, as in knock-knee and bow-knee. In bacterial diseases originating in the marrow, if the epiphysial junction is directly involved in the destructive process, its bone-forming functions may be retarded or abolished, and the subsequent growth of the bone be seriously interfered with. On the other hand, if it is not directly involved, but is merely influenced by the proximity of an inflammatory process, its bone-forming functions may be stimulated and the growth of the bone in length exaggerated. In paralysed limbs the growth from the epiphyses, although sometimes retarded or arrested, is usually little short of the normal. The result of interference with growth is more injurious in the lower than in the upper limb, because, from the functional point of view, it is essential that the lower extremities should be approximately of equal length. If the growth of one of two parallel bones is arrested, as in the forearm or leg, the continued growth of the other results in a deviation of the hand or foot to one or other side.

In certain constitutional diseases, such as rickets and inherited syphilis, all the epiphysial junctions of the skeleton may have their activities retarded, in which case dwarfing of the individual results.

Regeneration of Bone.—When bone has been lost or destroyed as a result of injury or disease, it is capable of being reproduced, and the extent to which regeneration takes place varies under different conditions. The chief part in the regeneration of bone is played by the periosteum, in virtue of the active functions possessed by the layer of osteoblasts on its deep surface. Provided the periosteum has been preserved, the whole shaft of a long bone may be reproduced after having been destroyed by disease or removed by operation. The reproductive capacity of the periosteum covering the epiphyses is usually more restricted ; were it otherwise, the exaggerated formation of new bone which sometimes occurs after injury or disease might interfere with the movements of the adjacent joint more frequently than it does. Similarly, the periosteum of the flat bones of the skull and of the bones of the face, which are primarily developed in membrane, has very little capacity of forming new bone ; hence, when bone has been lost or removed in these situations, there often results a permanent gap or defect, even although the periosteum has been preserved.

The marrow plays a minor part in the regeneration of bone. It is chiefly of service in eating away or removing periosteal bone which is not permanently required, and in modelling the new bone according to the architectural requirements of the part. When the marrow has been destroyed by disease, or scooped out in the course of an operation, the formation of new bone may result in the obliteration of the medullary canal.

Wounds or defects in articular cartilage are repaired chiefly by the formation of fibrous or osseous tissue.

Transplantation of Bone—Bone-grafting.—There is still considerable difference of opinion as to the fate of portions of bone which have been removed from their native soil and implanted elsewhere, or reimplanted in the situation from which they were detached. According to Barth and others, the implanted portion of bone remains quite passive, like any other aseptic foreign body, such as ivory or calcined bone, and is gradually penetrated by the surrounding vessels and tissue elements, and finally replaced by new bone. Clinical experience is conclusive that a portion of bone which has been completely detached from its surroundings—for example, a trephine circle, or a flap of bone detached with the saw, or the loose fragments in a compound fracture—may unite if replaced in position, and may after an interval present a surface which is absolutely intact, while at its margins it is firmly and permanently incorporated with the surrounding bone. Embedded foreign bodies, on the other hand, such as ivory pegs or decalcified bone, exhibit, on removal after a sufficient interval, evidence in the shape of worm-eaten depressions and perforations of having been eroded.

Transplanted living bone retains its vitality, not only when embedded in bone-forming tissues, but also when embedded in the soft parts, as is evidenced by the result of operations in which bone has been transplanted to form a new bridge to the nose.

DISEASES OF BONE.

Definition of Terms.—Any inflammatory process which affects the periosteum is spoken of as *periostitis;* while the term *osteomyelitis* is employed when the inflammation occurs in the marrow. In using these terms, however, it should be remembered that they only indicate the seat of the morbid process, but give no information regarding its nature. This is conveyed by prefixing such qualifying adjectives as pyogenic, tuberculous, or syphilitic to the terms *periostitis* or *osteomyelitis.* The term *ostitis* is intended to convey the idea of an inflammatory process in bone apart from periostitis or osteomyelitis; but as it is doubtful if this ever occurs, we abstain from using the term. The term *epiphysitis* has been applied to an inflammatory process in two distinct situations—namely, the ossifying nucleus in the epiphysis and the ossifying junction between the epiphysial cartilage and the diaphysis. We shall restrict the term to inflammation in the first of these situations. Inflammation at the ossifying junction is included under the term osteomyelitis.

The term *rarefying ostitis* has been employed to indicate any inflammatory process in the marrow which is attended by an excessive absorption of the rigid framework of bone, whereby it becomes looser in arrangement or more spongy than it was before. It is to be regarded as an accompaniment or as a result of different diseased conditions in the marrow, rather than as a separate entity.

The term *caries* is employed to indicate any diseased process associated with a crumbling away of the framework of a bone. It may be considered as the equivalent of the term ulceration as applied to soft parts. The carious process is always preceded by the formation of granulation tissue in the marrow or periosteum. The subsequent degeneration, or liquefaction of the granulation tissue into pus, necessarily results in destruction of the trabecular framework of the bone, whereby it is rendered soft and friable, and thus readily crumbles away. Clinically, carious bone yields a soft grating under the pressure of the probe. The student should regard caries, not as a disease in itself, but as the result of different diseases, and should therefore always add a qualifying adjective, such as suppurative, tuberculous, or syphilitic, which will indicate its nature.

The term *dry caries* or *caries sicca* is applied to that variety which is unattended with suppuration; it is well illustrated by the changes met with in the articular surfaces in certain forms of tuberculous disease of joints.

Necrosis is the term applied to the death of a tangible portion of bone, and the separated portion is called a *sequestrum*. The term *exfoliation* is sometimes employed to indicate the separation or throwing off of a superficial sequestrum. Necrosis is regarded as the equivalent of sloughing or gangrene in soft parts, and, like caries, is to be looked upon as the result of disease and not as a separate entity.

It should be clearly understood that the different morbid processes met with in bone originate in the same way and lead to the same general results as do similar processes in other tissues. The structural peculiarities of bone, however, and the important changes which take place in the skeleton during the period of growth modify certain of the clinical and pathological features.

Our conceptions of the nature of the diseases which affect the skeleton have been rendered clearer and more accurate by the demonstration of the bacterial origin of the great majority of them.

Classification of Diseases of Bone.—We shall consider the diseases of bone under the following headings:—Bacterial Diseases; Parasitic Diseases; Trophic Diseases; Tumours and Cysts of Bone.

BACTERIAL DISEASES.

The most important diseases in this group are the pyogenic and the tuberculous. It is convenient also to include the lesions of syphilis, although the causal organism has not yet been satisfactorily demonstrated.

In the majority of these diseases the organisms reach their seat of action in the bones by way of the blood-stream, having entered the circulation either from a pre-existing focus of disease in another part of the body, or through the skin or one of the internal mucous surfaces. In certain cases the infection takes place directly, either through a wound or from a contiguous area of disease.

Pyogenic Diseases of Bone.—These diseases result from infection with pyogenic organisms, and are most commonly met with while the growth of the skeleton is in active progress. They include not only all the conditions which run an acute course and are attended with the formation of pus, such as acute suppurative osteomyelitis, but also certain affections which run a more chronic course and are not associated with suppuration.

Diseases caused by the Staphylococcus Aureus.—Inasmuch as the vast majority of pyogenic diseases are due to infection with the staphylococcus aureus, these will be described first. They include—1. Acute Suppurative Osteomyelitis and Periostitis; 2. Serous or Albuminous Osteomyelitis and Periostitis; 3. Growth Fever; 4. Relapsing Osteomyelitis, including abscess of bone; and 5. Osteomyelitis which is chronic from the outset.

Acute Osteomyelitis and Periostitis.—The bone marrow during the period of growth constitutes a specially favourable seat for the deposition and development of staphylococci. In some cases a possible source of infection through the skin exists in the form of eczema, acne pustules, small infected wounds, or septic conditions at the umbilicus in the newly born. The internal mucous surfaces are perhaps the more frequent site of entrance of the cocci. Although proof of this is rarely obtainable, it is rendered probable by osteomyelitis being sometimes preceded by excoriations and fissures in the mouth and nose, by adenoids, small tonsillar abscesses, or by intestinal disturbances, such as diarrhœa. Staphylococci may enter the general circulation and be deposited in a living state in the marrow without there being any immediate evidence of such infection, or only such minor disturbances of health as may be indicated by slight indisposition or feverishness, and shooting "rheumatic" pains in the limbs.

Conditions causing extravasation of blood into the tissues or disturbing their nutrition, may act as localising factors in the production of osteomyelitis—as, for example, a blow or other form of injury, some extra exertion such as a long walk, or exposure to cold, as in wading.

That staphylococci may persist in the bone marrow in a condition of potential vitality for months or years must be assumed, otherwise the outbreak of acute osteomyelitis soon after an injury would in many cases be impossible of explanation. That they are capable of lying latent is also evidenced by the fact that the disease may break out afresh, on one or on several occasions, after apparent cure of the original attack.

The long tubular bones are affected in the following order of frequency:—The lower end of the femur, or either end of the tibia; the upper end of the humerus; the ulna, the fibula, the radius; the metatarsals, metacarpals, or phalanges. The other bones of the skeleton, such as the skull, ribs, and pelvis, are only affected in rare instances.

The disease is common in children, but is rare after the skeleton has attained maturity. Males are affected more often than females in the proportion of three to one, probably because they are more exposed to injury and to violent exertion. The disease does not necessarily pick out the weakly, but may affect robust children. It not uncommonly, however, follows other infective diseases, such as scarlet fever or typhoid.

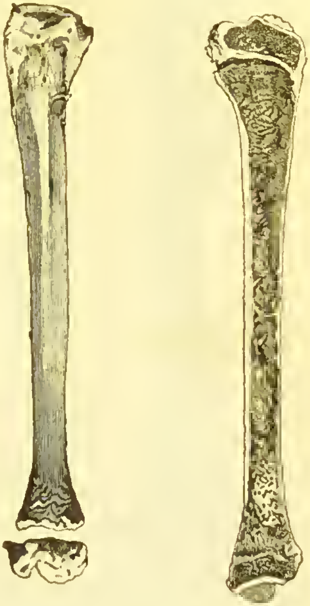
FIG. 178.—Acute Bipolar Osteomyelitis of Tibiæ, showing separation of epiphyses.

Pathology.—It must be emphasised that during the period of growth this disease nearly always commences in the marrow, suppuration under the periosteum being usually a secondary manifestation, even although, as often happens, the symptoms of periosteal suppuration predominate clinically. As a rule, the disease commences and is most intense in the ossifying junction at one end of the bone. It may commence at both ends simultaneously—bipolar osteomyelitis—or at one end and spread to the other. Osteomyelitis in the marrow of the epiphysis itself (*acute epiphysitis*) is rare as an independent lesion.

When acute osteomyelitis attacks a long bone during the period of growth, the changes observed in the marrow are those of intense inflammation, gradually going on to purulent infiltration. Where the process is most advanced—that is, at the ossifying junction—there are evidences of absorption, rarefaction, and disappearance of the framework of the bone; the marrow spaces and Haversian canals are enlarged, resulting in the formation of visible tunnels and cavities which are occupied by greenish-yellow pus. These destructive changes are most marked in the region of the ossifying junction; the larger spaces are near the epiphysial disc itself, and they often communicate with the exterior through holes in the cortex, through which the pus may escape. The blood-vessels and tissue elements of the marrow undergo destruction, and the veins may become the seat of thrombosis and infective phlebitis.

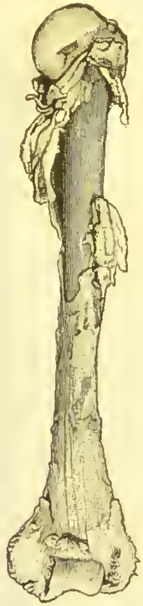

FIG. 179. — Acute Suppurative Periostitis of Humerus, showing stripping of periosteum from upper part of diaphysis.

Necrosis of a considerable portion, or of the entire bone in the region affected, may occur; hence the name "acute necrosis" formerly applied to the disease. The necrosis is mainly attributable to the poisonous action on the bone of the bacterial products in the pus with which it is in contact. Doubtless the vitality of the bone is seriously impaired by the vascular and tissue changes which attend the process, but the actual death is the result of the action of the toxins.

The inflammatory and suppurative process may remain localised to the ossifying junction, may spread along the medullary canal for a varying distance, or may extend through the cortex to the deeper surface of the periosteum by way of the Haversian canals. It then spreads along the deeper layer of the periosteum, and presents the features of periosteal inflammation and suppuration, the pus accumulating under the periosteum and lifting it up from the bone (Fig. 179). The periosteum of the diaphysis is easily separated—hence the facility with which the pus spreads along the shaft; whereas in the region of the ossifying junction the periosteum is raised with difficulty, because of its intimate connection with the epiphysial cartilage. Less frequently there are several distinct collections of pus under the periosteum, scattered up and down the shaft, each being derived from a focus of suppuration in the subjacent marrow. The subperiosteal pus may communicate with that in the marrow, and also with collections of pus in the overlying cellular tissue.

Where there is pus in the marrow there is nearly always pus under the periosteum, and the converse is usually true. The subperiosteal pus makes its way to the surface by the easiest anatomical route, erupts through the skin and discharges externally, forming a sinus. The spread may also tend in the direction of the adjacent joint, by extension under the periosteum and capsule, or through the epiphysis and articular cartilage, or from the periphery of the epiphysial junction, especially if the latter is entirely intra-articular—as is the case, for example, in the hip.

While the occurrence of purely periosteal suppuration is admitted, it is the exception in young subjects. When it does occur, and the pus is evacuated, the periosteum comes again into contact with the bone, and recovery is likely to take place without necrosis.

Changes in the Epiphysis and Ossifying Junction.—When there is marked absorption and destruction of bone at the ossifying junction, the epiphysis is liable to be separated. The separation—*epiphysiolysis* (Fig. 178)—may take place at the level of the epiphysial cartilage or through the ossifying junction, and the surfaces of the diaphysis and epiphysis are opposed to each other by irregular eroded surfaces bathed with pus. The separated epiphysis may be maintained in contact with the diaphysis by the periosteum, but when this membrane has been detached by the formation of pus beneath it, the epiphysis is liable to become displaced by muscular action or by some movement of the limb. Except in cases where the epiphysis is both separated and displaced, the epiphysial cartilage usually remains intact, and is quite capable of continuing its bone-forming functions. Where it has been seriously damaged, however, the future growth of the bone in length may be interfered with. Necrosis in the epiphysis itself is exceptional, and when it does occur, it is usually partial, in the form of small spongy sequestra; the whole epiphysis may die, however, and separate as a sequestrum; this is best seen in the head of the femur.

The adjacent joint may be influenced by the inflammation in the bone in such a way that it becomes filled with a serous effusion similar to that causing œdema in the soft parts. This effusion is usually found on examination to be sterile. When the joint is infected, the lesion assumes the characters of an arthritis, which, from its frequency during the earlier years of life, has been called *the acute arthritis of infants.*

Repair.—This begins when the acute stage of the process has subsided. The periosteum and marrow, wherever they have retained their vitality, resume their osteogenetic functions, often to an exaggerated degree. The initial changes in this direction consist in the formation of granulation tissue from the living periosteum and marrow.

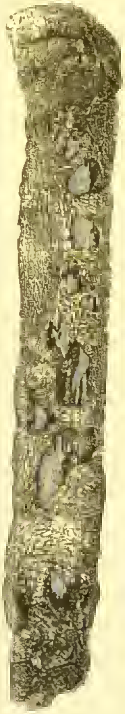

FIG. 180.—Shaft of the Tibia after Acute Osteomyelitis. The shaft of the bone has undergone extensive necrosis, and a shell of new bone has been formed by the periosteum.

(Specimen originally figured by James Syme in his *Principles of Surgery* and now in Mr. Annandale's collection.)

Wherever the periosteum has been lifted up from the shaft by an accumulation of pus, or is in contact with bone which is dead, it proceeds to form new bone with great activity, so that in the course of time the dead shaft becomes surrounded by a sheath or case of new bone, known as the *involucrum* (Fig. 180). Wherever the periosteum has been perforated by the pus making its way to the skin surface, there are defects or holes in the involucrum, called *cloacæ.* As these correspond more or less in position to the sinuses in the skin, in passing a probe down one of the sinuses it usually passes through the cloaca and strikes the dead bone lying in the interior. Where the periosteum has been more extensively destroyed, new bone may only be formed in small patches here and there, or not at all. The tissue cells and capillary loops on the internal aspect of the new case form a lining of granulations, which, if in immediate contact with the dying bone, eat into its surface and partly absorb it. The bone in the process of separation thus acquires a pitted, grooved, or worm-eaten appearance, and undergoes diminution in size. If the periosteal surface of the bone is bathed in pus, it remains smooth and intact. The separation of the dead bone from the living is effected by the activity of the cells of the marrow, chiefly osteoclasts, which eat both into the living and into the dead bone, so that separation takes place at the expense of both; ultimately the dead bone becomes loose. The separated dead bone or *sequestrum* usually presents on its surfaces and edges an eroded or worm-eaten appearance. The sequestrum is white, but it may be discoloured by the products of decomposition. The separation of sequestra is more rapid through the spongy bone at the end of the shaft than through the compact bone towards its centre, where the line of separation is often oblique.

Where the foci of suppuration have been scattered up and down the medullary cavity, and the bone has died in patches, several sequestra may be included by the new case. Each portion of dead bone is slowly separated, and comes to lie in a cavity lined by granulations.

As a result of formation of new bone by the marrow, the medullary canal may be obliterated, and the bone becomes heavier and denser—sclerosis. Wherever the periosteum has not been detached, the new bone which it forms is deposited on the original shaft, and results in increase in the girth of the bone—hyperostosis.

Pathological fracture of the shaft may occur before repair is complete. It occurs at the site of necrosis, where the new case is incapable of resisting the strain put upon it, and is most frequently met with in the shaft of the femur. Short of fracture, there may be bending or curving of the shaft from want of rigidity; this especially affects the new case, and results in great deformity and shortening of the limb.

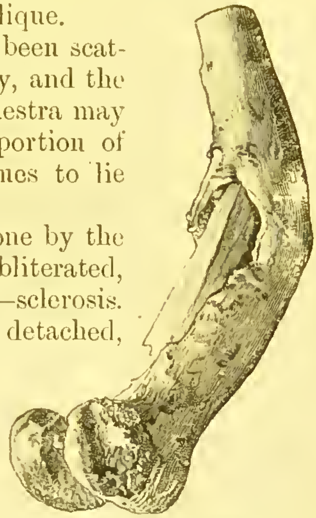

FIG. 181.—Large Sequestrum of Lower Part of Shaft of Femur partly surrounded by New Bone; the latter is bent as a result of fracture which took place 2½ years before amputation.

(Museum, Royal College of Surgeons, Edinburgh.)

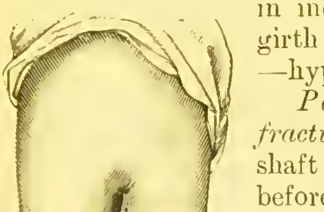

FIG. 182. — Sequestrum of Femur in process of Natural Extrusion.

(Mr. C. W. Macgillivray's case.)

The spontaneous extrusion of a sequestrum may occur from the pressure of granulations upon it, provided there is a cloaca large enough and so situated as to favour its escape (Fig. 182), but the surgeon has usually to interfere by performing the operation of sequestrectomy. Displacement or partial extrusion of the dead bone may cause serious complications, as when a sequestrum derived from the trigone of the femur perforates the popliteal artery or the cavity of the knee-joint.

The extent to which bone which has been lost is reproduced varies in different parts of the skeleton: while the long bones of limbs, the scapula, the lower jaw, and other bones which are developed in cartilage are almost perfectly reproduced, the articular ends of bone, and bones which are entirely developed in membrane, such as the flat bones of the skull and upper jaw, are not reproduced at all.

In infants, so long as the epiphyses are cartilaginous, they are to a large extent intra-articular, and osteomyelitis occurring at the ossifying junction is much more likely to involve the adjacent joint than to spread to the shaft of the bone, as it does in older children.

In the small bones of the carpus, tarsus, fingers and toes, the lesion assumes the characters of a joint disease. *In flat bones*, such as the skull, ilium, or scapula, periosteal suppuration is the predominant feature, and it may occur on both aspects of the bone.

Clinical Features of Acute Suppurative Osteomyelitis and Periostitis.—The symptoms may be divided into those which attend the entrance of the staphylococci into the system, and those which are associated with their localisation in the bones.

Constitutional symptoms resulting from the entrance of the staphylococci into the system may be absent, or so slight as to escape recognition. In severe cases they assume the features of delirium and prostration, and the patient may succumb before there is any evidence of the localisation of the staphylococci in the bones.

In the great majority of cases of osteomyelitis the onset of the disease is characterised by pain and tenderness on pressure. The pain may develop gradually or suddenly, and it may be so severe as to prevent sleep and cause the child to cry out. Tenderness on pressure is of great value in recognising the seat of the lesion and the part of the bone affected. The constitutional symptoms which accompany these local features vary considerably in different cases. The temperature usually rises with a rigor to 102° or 104° F., and runs a very irregular course, with slight morning remissions; the pulse is rapid; there is headache, loss of appetite, vomiting, and sometimes delirium and convulsions.

A little later there develop more characteristic local signs, such as swelling in the region of the ossifying junction, œdema of the soft parts, and dilatation of the superficial veins. The swelling does not appear at once, because the inflammation usually originates in the marrow. It appears earlier in superficial bones, such as the tibia, ulna, or clavicle, than in the femur or humerus. The swelling may be less evident to the eye than to the fingers, and is best appreciated by palpating the bone from the middle of its shaft towards its end. The maximum thickening of the bone and the tenderness correspond to the junction of the shaft with the epiphysis, and the swelling tails off gradually towards the diaphysis. As time goes on, there is diffuse redness of the skin, especially over superficial bones, such as the tibia. The swelling becomes elastic and yielding, and gives definite evidence of fluctuation. This stage may be reached at the end of twenty-four hours, or not for many days. When the affected bone is deeply seated,—as, for example, the upper end of the femur or humerus,—the swelling takes longer to develop and is ill-defined.

Suppuration spreads towards the surface, until, at the end of from ten days to a fortnight, the swelling bursts and the pus escapes. The pus may contain blood and droplets of fat derived from the marrow, and in some cases minute particles of bone are present also. The presence of fat and bony particles in the pus may be of service in confirming the medullary origin of the suppuration. After the escape of the pus the fever usually remits and the pain and other symptoms are relieved.

If an operation be performed, the periosteum is found to be lifted up from the bone by the pus, and the extent of the bare bone corresponds fairly accurately with the distribution of the lesion in the marrow. Sometimes there are perforations in the cortex of the bone through which the pus may be seen to escape.

Local Complications.—The adjacent joint may be implicated, and exhibit symptoms which vary from those of a simple effusion to those of *acute arthritis.* The joint symptoms may account for little in the clinical picture, or may so predominate as to overshadow those of the bone lesion from which they originated,—in the latter case with the result that the suppuration in the bone is liable to be overlooked.

Displacement of the epiphysis may take place insidiously, and reveal itself by an alteration in the attitude of the limb, which may resemble that of a dislocation. Complete separation is nearly always associated with suppuration in the adjacent joint.

When *pathological fracture* of the shaft occurs, as it may do, from some muscular effort or strain of the limb, it is attended with the usual signs of fracture.

Pathological dislocation has been chiefly observed at the hip, and it may or may not be associated with suppuration in the joint. Curious combinations are sometimes met with, such as suppurative osteomyelitis in the shaft of the femur on one side, and dislocation of the hip without suppuration on the other.

In some cases the *multiplicity of the lesions* in the bones and joints imparts to the disease features which are those of pyæmia. The occurrence of septic endocarditis, as indicated by alterations in the heart sounds and the development of murmurs, may cause widespread infective embolism, and metastatic suppuration in the internal organs as well as in the bones and joints. The secondary suppurations are liable to be overlooked unless carefully sought for, as they are rarely attended with much pain.

In these graver forms of osteomyelitis, the patient may be dull and listless, or restless and talkative, or he may be actually delirious. The tongue is dry and coated, the lips and teeth are covered with sordes, the motions are constipated, or they may be loose and offensive, and may be passed involuntarily. The temperature is remittent and very irregular, the pulse is small and rapid, and the urine is scanty and may contain blood and albumin. The skin may show erythematous and purpuric rashes, bleeding may take place from the nose and mouth, bedsores may form over the sacrum, the belly may be swollen and sensitive, and the patient may cry out as in meningitis. Death usually takes place within a few days of the onset of the illness.

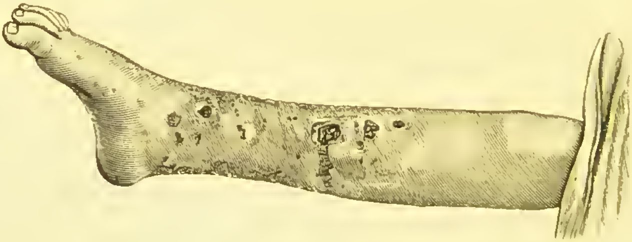

FIG. 183.—Thickening and Multiple Sinuses resulting from Acute Osteomyelitis of Tibia, in a girl æt. 12.

Sequelæ of Acute Suppurative Osteomyelitis.—The patient may not apply for treatment until the acute stage has passed off and sinuses have formed. These sinuses have rigid edges which are usually depressed and adherent to the subjacent bone. They tend to be persistent, and generally imply the presence of a sequestrum.

In the pelvis, the sequestrum has been known to make its way into the bladder, and give rise to the symptoms of stone.

In the lower end of the femur it may penetrate the knee-joint, or perforate the popliteal artery. If the sinus persists for many years, it may become the seat of epithelioma.

The *deformities* resulting from acute osteomyelitis are more marked the earlier in life the attack occurs. *Shortening* is not uncommon from interference or arrest of growth at the epiphysial junction. The loss in length corresponds to the extent of destruction of the ossifying tissues, and to the functional value of the epiphysial junction concerned. *Exaggerated growth* in the length of a bone is very rare, but it has been observed in the bones of the leg. Where there are two parallel bones—as in the leg, for example—the growth of one bone may be impaired or arrested, and the other continuing to grow, becomes disproportionately long. Less frequently the growth of the diseased bone may be exaggerated, and it becomes the longer of the two. In either case, the bone which is abnormally long becomes curved. An *obliquity* of the bone may result where one half of the epiphysial cartilage is destroyed, and the other half continues to form bone, and this gives rise to such deformities as genu valgum, cubitus valgus, and club-hand.

There is sometimes bending of a single bone, such as the femur or humerus, from the yielding character of the new case, and this is associated with evident deformity, consisting in shortening and alteration of the axis of the limb.

Deformity may also result from vicious union of a pathological fracture, permanent displacement of an epiphysis, contracture, ankylosis, or dislocation of the adjacent joint.

Differential Diagnosis.—The acute stage of osteomyelitis is to be diagnosed from erysipelas, cellulitis, and other inflammations of the overlying soft parts. Errors are most likely to occur in the case of superficial bones, such as the tibia, clavicle, or ulna. Tenderness localised to the site of the epiphysial junction is a valuable diagnostic sign of osteomyelitis. Erythema nodosum also has been mistaken for osteomyelitis of the tibia.

When there is early and pronounced general intoxication, the severe forms of osteomyelitis are most likely to be confused with certain fevers, such as scarlet fever. In all febribe conditions in children and in young adults, the ossifying junctions of the long bones should be examined for areas of pain and tenderness.

Acute osteomyelitis has many features in common with acute articular rheumatism, and some authorities believe them to be different forms of the same disease (Kocher, Sahli) The lesions, however, are usually multiple in acute rheumatism, and solitary in osteomyelitis. The pain and tenderness are over the joints in acute rheumatism, and over the bone in osteomyelitis. Swelling is articular in acute rheumatism, and extra-articular in osteomyelitis. The pains and temperature yield to salicylate of soda much more decidedly in acute rheumatism than in osteomyelitis.

The *prognosis* in acute suppurative osteomyelitis varies with the type of the disease, the initial severity and prominence of the symptoms of intoxication, with the seat of disease,—the vertebræ, skull, pelvis, and lower jaw being specially unfavourable,—with the multiplicity of the lesions, and with the development of septic endocarditis and of internal metastases.

Treatment.—This is carried out on the same lines as in other suppurative diseases. The strength of the patient is to be kept up by abundant and easily absorbed nourishment. Kocher advocates the liberal exhibition of fluids by the stomach, the rectum, or by subcutaneous infusion, so as to keep up the blood pressure, to wash out toxins, and to promote excretion by the kidneys and skin. Considerable relief may result from the administration of full doses of salicylate of soda.

The limb is to be wrapped in a moist antiseptic dressing, and laid on a pillow, or immobilised in some form of splint, while the necessary preparations for operative treatment are being made.

The most important indications are to evacuate the pus as early as possible, and to avoid introducing any fresh infection. So far as the suppuration under the periosteum is concerned, the above indication is fulfilled by a limited incision, and the insertion of a rubber or glass drainage tube.

It is sometimes difficult to decide whether or not the medullary cavity should be opened. Indications of the necessity of opening into the marrow are often present, such as the presence of fat droplets or bone particles in the pus, the oozing of pus through holes in the cortex, or signs of commencing separation at the ossifying junction. In the absence of such indications, opening into the marrow may be deferred until the persistence of fever and other symptoms of intoxication indicate the certainty of there being purulent infiltration in the interior of the bone. Necrosis is less common and less extensive after such operations than without them. There is less inclination to explore the medullary cavity in deeply seated bones,—for example, the pelvis or the femur,—as free access cannot be obtained without a severe operation.

The Operation of Clearing out the Marrow.—The frequency with which the disease originates at the ossifying junction renders it advisable that the bone should be opened in this region in the first instance by means of a small trephine or gouge. If pus is found, additional openings may be made according to the extent of the lesion in the marrow, and these may be converted into one open gutter.

The *immediate resection of the diseased shaft* is rarely called for. It is better, as a rule, to wait, because one cannot prophesy the extent of the necrosis and more may be removed than is necessary. The shaft may, however, be resected with advantage when the suppuration is very abundant, and when the bone is extensively bared and appears likely to die. If the epiphysis is bathed in pus and extensively separated, it may be necessary to remove it.

Amputation of the limb, which was at one time a frequent resource in suppurative osteomyelitis, is now very rarely called for. It is reserved for grave cases in which life is endangered from general infection, or where the limb is likely to be useless—as, for example, when several joints are involved, when there is separation and displacement at the epiphysial junction, and when the whole shaft is dying or dead and there is no appearance of a new case.

Flat bones, such as the skull or ilium, must be trephined early, because there may be suppuration on both aspects of the bone. In the os calcis, patella, and similar bones, interference must be early, in order to save the adjacent joint. In the vertebræ, treatment is directed to the evacuation and drainage of the abscess.

Treatment of the Necrosis.—When the patient comes under observation after the acute symptoms have disappeared, treatment may be required for the sequelæ of the disease. So long as dead bone remains in position, so long will there be suppuration from the granulations lining the cavity in which it lies, and a discharge of pus externally through the sinuses. The dead bone may be evident to the eye, but it is usually only recognised on passing a probe down a sinus.

It is not easy from external examination alone to determine the size, character, or number of the sequestra, or to be certain of their mobility. As regards surgical interference, the general rule is to wait until the sequestrum is separated. In premature operations for necrosis diseased portions may be left behind, or an unnecessary amount of bone may be removed, and subsequent repair interfered with. While waiting for separation of the sequestrum, drainage should be improved, and the septic element combated. In exceptional cases, where the sequestrum is very slow in separating, as in the outer table of the skull, or where there is risk from sepsis, operation may be undertaken before separation is complete, care being taken to chisel well beyond the disease into the surrounding vascular bone.

The operation for the removal of the dead bone (*sequestrectomy*) consists in opening up the periosteum and the new case to a degree sufficient to allow of the removal of all the dead bone, including the most minute sequestra, as well as any areas of infected granulation tissue and pus. A tourniquet may be employed with advantage. Existing sinuses may be enlarged, but if these are inconveniently situated—for example, in the centre of the popliteal space in necrosis of the femoral trigone—it is better to make a fresh wound down to the bone on that aspect of the limb which affords the best access and which entails the least injury of the overlying soft parts. The periosteum, which is thick and easily separable, is raised from the new case with an elevator, and by means of the chisel or gouge the newly-formed bone is removed to such an extent as will allow of removal of the sequestrum. In exposing and removing the sequestrum, care is taken not to break off and leave behind any fragment from its worm-eaten edges and extremities, for if any such fragment is allowed to remain, it will interfere with healing, or determine a relapse of suppuration at a later period.

The dead bone having been removed, the cavity in which it lay is disinfected by scraping away the lining granulations with the sharp spoon, and swabbing the raw surface with pure carbolic acid. The cavity may then be stuffed with iodoform worsted, the stuffing being renewed from time to time until healing is completed. To prevent the worsted sticking into the rough bone, the intervention of a sheet of oil-silk protective is sometimes employed.

On account of the time and trouble connected with this method of treating bone cavities, other procedures may be undertaken. The cavity may be allowed to fill up with blood-clot, and, provided there is perfect asepsis, it may be possible in this way to obtain healing under a single dressing. When the cavity is in a superficial bone, it may be filled in by means of a flap raised from the adjacent healthy bone. In other cases the cavity may be filled with bone grafts, such as fragments of living bone obtained in resection of club-foot, or fragments of calcined bone. Lastly, the walls of the rigid cavity may be mobilised by means of the chisel, so that they may be brought into contact. These procedures, designed to promote the healing of bone cavities, may be carried out at the same time as the sequestrum is removed, or after an interval.

Serous or Albuminous Osteomyelitis and Periostitis.—This is a mild or benign form of the acute disease. The virulence of the infecting agent being attenuated, the inflammatory exudation is serous in character, and shows no tendency to end in suppuration. The periosteal element predominates, and death of bone is exceptional. It is nearly always localised, and there are neither multiple lesions nor metastases. It is characterised by symptoms similar to those met with in suppurative osteomyelitis; the fever, however, subsides rapidly, and the local phenomena of inflammation are not severe. The amount of periosteal exudation is considerable in comparison with the mildness of the general symptoms.

As the condition is liable to be mistaken for a blood cyst or a cold abscess, the diagnosis is not usually made until the swelling is incised, and there escapes a variable quantity of a transparent, amber-coloured fluid, like synovia, in which there may be oil droplets from the marrow. In cases following directly on injury, there may be a good deal of blood mixed with the exudation. The treatment consists in incision and drainage.

Growth Fever (Fièvre de croissance) is a condition described by French authors, which is of the nature of osteomyelitis, but is unattended with exudation, suppuration or necrosis, and results in an exaggerated growth in length of the bones affected. It may be the explanation of the condition popularly known in this country as "growing pains" and that form of "rheumatism" which is often met with in the lower limbs of children and adolescents.

It is regarded by most observers as an attenuated form of staphylococcal osteomyelitis. Attention is usually directed to it by the remarkable stimulus which the growth of the skeleton may receive in young subjects, especially during or shortly after an acute illness, such as typhoid fever.

Clinically, two types may be recognised according to the presence or absence of fever. *In the non-febrile form* the child complains of vague evanescent pains, and of feeling tired, and he is disinclined to go about. After a walk or other exertion he may complain of more severe pain in the limbs, sometimes referred to the joints. The pains may disappear after a night's rest, may last for several days, or they may come and go over a considerable period. Recovery with increase in stature is the rule.

In *the febrile form* the child is evidently ill, has no appetite, is weary and disinclined to get up, has pains in the head, and in the region of the joints of the limbs. At times, and especially in the evening, the skin is hot and burning, and the temperature may rise considerably. The illness may be sudden and acute, and may last for two or three days, or may be milder and more prolonged, and there may be several relapses within twelve months. The increase in stature may amount to as much as from four to six inches in a year.

In the diagnosis reliance is to be placed chiefly on the occurrence of variable attacks of fever with pains and tenderness at the epiphysial junctions. It may be mistaken for typhoid and other fevers, tuberculous meningitis, and tuberculous diseases of bones and joints. Growth fever is less common than any of these. Localised forms at the hip and in the spine may be mistaken for tuberculosis.

The prognosis is essentially favourable, but, if carelessly treated or neglected, the condition may pass into the form of osteomyelitis attended with suppuration.

The treatment consists in improving the general health by fresh air, sunlight, good food and attention to the bowels, and during the persistence of the pains the patient is kept at rest with the affected limb immobilised.

Relapsing Osteomyelitis.—Relapsing osteomyelitis dates back to an acute attack which has been recovered from, but which has left behind it foci of infection containing staphylococci, which lie dormant in the marrow. At any time, as a result of influences at present unknown, but probably aided by depression of general health, by injury or by exposure to cold, these may again become active and cause a fresh outbreak of the disease.

The original attack may have been a comparatively mild one, and may have attracted little notice, or it may have been one attended with acute illness, suppuration, and necrosis. The relapse may take place within a few months of the original attack or not for many years, and there may be only one relapse or there may be repeated outbreaks. Cases are sometimes met with in which a relapse occurs annually with remarkable regularity for several years, the tendency, however, being for each attack to become milder as the virulence of the organisms becomes more and more attenuated. Osteomyelitis in a patient over twenty-five is usually of the relapsing variety, and in a majority of cases the history of a previous attack can be elicited. The anatomical features of the lesion are influenced by the fact that the structure of the bone has been altered by the original attack of osteomyelitis, and by the fact that the bone is fully grown.

Clinical Features.—In contrast to the original attack the local features predominate: they consist in pain, tenderness on pressure, swelling and redness. There may be an entire absence of general illness, so that the patient may continue his occupation. The surgeon's attention may be called to traces of the original attack in the shape of deformity of the bone, depressed, adherent scars, or impaired function of the adjacent joint. Where progressive thickening of the bone (hyperostosis and sclerosis) is the chief element, the patient complains of aching pains, the bone is enlarged, and may be very tender on pressure at one point. When suppuration occurs, it is often remarkably latent, and the pus is slow in coming to the surface.

The pus which forms in relation to the bone may escape by new channels, or an old sinus may open up in continuity with the original cloaca in the bone. If there be a sequestrum, it is often of long standing, and being buried or walled in by new bone, is difficult to discover and remove. When the lesion is situated near the articular end of the bone, it may be associated with changes in the adjacent joint, such as swelling and stiffness, which are liable to be regarded as the result of tuberculosis or some other form of primary joint disease.

These relapsing forms of osteomyelitis, although rarely dangerous to life, may, by laying the patient up at intervals, seriously interfere with his occupation. This is especially true of cases in which sinuses in relation to necrosis in the trigone of the femur are constantly breaking out afresh, sometimes in spite of repeated attempts to cure the condition by operation.

The *treatment* varies with the nature of the lesion. In cases of hyperostosis and sclerosis with persistent and severe pain, relief may be afforded by the repeated application of blisters ; failing relief, the thickened periosteum should be incised, or the bone itself should be opened up with the chisel or trephine. In cases attended with suppuration, the swelling is incised and drained ; if there is a sequestrum, this should be removed.

Circumscribed Abscess of Bone—"Brodie's Abscess."—A circumscribed abscess in the interior of a long bone is most often met with in youths or adults who have suffered from a previous attack of osteomyelitis. It therefore belongs to the relapsing type above described. Several years usually intervene between the original osteomyelitis and the onset of the symptoms of abscess. The presence of scars which are depressed and adherent to the bone may afford proof that the primary disease was attended with suppuration. The patient may, however, be unaware of having suffered from any previous disease in the bone, and it is quite possible that the attack may have been of so mild a character as to have escaped recognition.

Morbid Anatomy.—The abscess is usually situated near one of the extremities of a long bone, probably because of the frequency with which staphylococcal osteomyelitis is located at the ossifying junction. The commonest situation is in the upper or lower end of the tibia, and next in frequency the lower end of the femur, the upper end and then the lower end of the humerus. Exceptional cases are met with, however, in which the abscess is situated in the middle of the shaft, and in which there are two or more abscesses quite separate from one another.

At the site of the abscess the bone is usually enlarged and increased in girth ; its surface is uneven owing to the irregular formation of new bone by the periosteum. In some cases the bone is not only larger and heavier than the normal, but is also longer, and may be curved or otherwise misshapen as a result of the antecedent osteomyelitis. On section of the shaft, the abscess is found to be definitely circumscribed and walled in by bone which is usually hard and dense. The abscess is lined by a delicate membrane composed of granulation tissue. The staphylococcus aureus can usually be cultivated from the pus, which is of a greenish yellow colour. In a considerable proportion of cases, a sequestrum is found lying loose in the cavity. In addition to the sclerosis in the vicinity of the abscess, the whole shaft may be condensed, and the medullary canal obliterated.

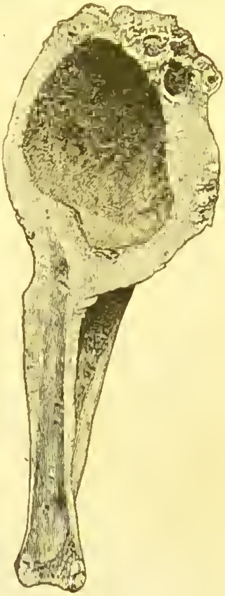

Fig. 184.—Enormous Enlargement of Upper End of Tibia from an Abscess in the Interior. The cavity was large enough to contain 16½ ounces of fluid. (Museum of Royal College of Surgeons, Edinburgh.)

In size, the abscess varies from that of a pea to a walnut ; in exceptional cases it may attain the size of a cocoanut (Fig. 184).

The adjacent joint may be implicated. There may be a sinus opening into the joint. More commonly there is an effusion of fluid into the joint, constituting one of the forms of relapsing or intermittent hydrops, or the joint becomes stiff as a result of adhesions and the conversion of the articular and inter-articular cartilages into fibrous tissue.

Clinical Features.—Pain is the predominating feature ; it is continuous, neuralgic, and deep-seated, with exacerbations, especially at night, when it may become excruciating. The patient's suffering may have continued over a period of many years, sometimes with intervals during which the pain was absent and he was able to go about his work. On examination, the bone is found to be enlarged. There is usually one spot where there is great tenderness, and this is best elicited by percussing the bone. Elevation of temperature is exceptional.

The patient may complain of swelling and stiffness in the adjacent joint, and this may be chiefly responsible for his incapacity to use the limb.

The *diagnosis* is not difficult in typical cases. Sometimes, however, the characteristic pain and tenderness may be absent at the time of examination. In cases in which the patient refers all his complaints to the adjacent joint, and especially if the latter is obviously implicated, the existence of an abscess in the interior of the bone is liable to be overlooked. The results obtained by examination with the X-rays are often misleading, because the sclerosis of the bone around the abscess may give a uniform dark shadow, and thus obscure the appearances of a cavity. Great attention should be paid to the previous history, bearing in mind that a Brodie's abscess is most frequently met with in young men who have had a previous attack of osteomyelitis.

Treatment.—If an abscess is suspected, there should be no hesitation in exploring the interior of the bone. Such an exploration usually relieves the sufferings of the patient, whether there is an abscess or not. The affected segment of bone is exposed by a suitable incision, and the periosteum reflected, the bone is opened up by means of a trephine or chisel, and the presence of an abscess may be at once indicated by the escape of pus. If this procedure fails to strike the abscess, the bone should be drilled or tunnelled in different directions, as it is often difficult to discover because of its relatively small size and the density of the bone surrounding it. Having cleared out the pus and any dead bone, the cavity is scraped and disinfected, and after being packed with iodoform worsted is treated by the open method.

In young subjects, if the shaft of the bone is much thickened and distorted, the portion containing the abscess may be resected with every confidence that the periosteum will form new bone in its place.

Osteomyelitis which is Chronic from the Outset.—The pyogenic origin of osteomyelitis which is chronic from the outset has only been recognised within recent years. It was formerly confused with syphilis and tubercle, and without bacteriological examination is still difficult to differentiate from these. Like relapsing osteomyelitis, it may assume the form of hyperostosis and sclerosis, of suppurative osteomyelitis with or without necrosis, or of chronic abscess of bone.

Necrosis without suppuration, which was first described by Sir James Paget under the name "quiet necrosis," is a rare disease, and would appear to be associated with an attenuated form of staphylococcal infection acting over a long period (Tavel). It occurs in adults, being met with up to the age of fifty or sixty, and affects both sexes equally. There may be no discoverable explanation of its occurrence, or, on going into the history, it may be found to date back to some infective disease, such as typhoid, years before.

It is characterised by the development, without any apparent cause, of pain and swelling, involving a considerable extent of the femur or tibia. The pain varies in intensity, and may be continuous or remittent. There is tenderness on pressure. The shaft of the bone is increased in girth, as a result of its being surrounded by a new case derived from the periosteum. The resemblance to sarcoma may be very close, but the swelling is not so defined as in sarcoma, nor does it ever assume the "leg of mutton" shape characteristic of the latter. In both diseases there is a tendency to pathological fracture. The condition is also differentiated with difficulty from syphilitic and from tuberculous disease.

The anatomical peculiarities of this disease, apart from the absence of suppuration, are, the incomplete distinction between the dead and the living bone, the length of time required for the separation of the sequestrum, the absence of any cloaca in the new case, and the formation of new bone both on the external and internal aspects of the tubular sequestrum which represents the original shaft.

Many of these characters are illustrated in tuberculous and syphilitic necrosis. They are to be ascribed partly, no doubt, to the fact that the disease is practically confined to the bones of adults, but chiefly to the very attenuated form of the infecting virus giving rise to it, the virus in this respect resembling that of tubercle or syphilis.

The treatment consists in removing the sequestrum on the usual lines. The symptoms are relieved in any case by trephining the bone.

Osteomyelitis and Periostitis due to Pyogenic Infections other than Staphylococci.—It has been hitherto assumed that the majority, including all the typical forms of osteomyelitis, are the result of infection with the staphylococcus aureus. Any micro-organism, however, with pyogenic properties may cause osteomyelitis.

In infections with the *staphylococcus albus* the disease is usually milder, and is less frequently followed by necrosis.

The *streptococcus pyogenes* is rarely met with as a pure infection, and occurs chiefly in infants. The onset of the illness may be very acute, but the symptoms tend to subside in a few days, when pus forms. Joint complications are comparatively frequent, the pains are less severe; suppuration occurs earlier, and is more diffuse and abundant.

The *pneumococcus* causes medullary infections which have been met with especially in the earlier years of childhood. They are relatively benign, for although the general symptoms may be grave to start with, the local lesions are less severe, as if the virulence of the infection were soon exhausted. The joints are affected more frequently than the bones. Incision of the purulent collection in relation to the bone is usually sufficient, as there is little tendency to the formation of sequestra. Some slight thickening of the bone, or a few adhesions in the adjacent joint, may remain, otherwise recovery is usually rapid and complete.

The *Typhoid Bacillus.*—During typhoid fever, the bone marrow is markedly congested, which appears to favour the lodgment of the bacilli, and when lodged, they are capable of persisting for long periods until some injury or other factor determines their return to active life.

The lesions in the bones may or may not be attended by suppuration, and they may involve the marrow or the periosteum, or both. They may be solitary or multiple. Their favourite seat is in the tibia and in the ribs at the costo-chondral junctions. Where unattended by suppuration, the disease may recover completely, or apparently recover, and then relapse. When pus is formed, it usually presents on examination a pure culture of the typhoid bacillus. The abscess may be dumb-bell shaped, one part being under the periosteum, and the other in the marrow.

The bone lesions usually occur during the seventh or eight week of the disease. There is little disturbance of the general health, and fever may be absent altogether. The chief complaint is of vague pains in the bones. After being referred to several bones, these usually become localised in one; they are aggravated by movement, or by handling the bone, and are worst at night. They may disappear spontaneously, but may reappear later. There is redness and œdema of the overlying soft parts, and swelling with vague fluctuation over the bone, and on incision there escapes a yellow creamy pus, or a brown syrupy fluid. Necrosis is exceptional.

Where the abscess develops very slowly, the condition may resemble tuberculous disease of the bone. Stress is to be laid on the history of typhoid, and on the bacteriological examination of the pus.

The prognosis is favourable in pure infections with the typhoid bacillus, but recovery is apt to be slow, and relapse is not uncommon.

In the treatment of typhoid lesions it is usually sufficient to incise the periosteum. In the case of the ribs, it may be necessary to resect portions of bone.

Mixed Infections.—Regarding mixed infections with combinations of pyogenic organisms, very little is known, but they are usually regarded as more serious than pure infections. Infections following the eruptive fevers, such as scarlet fever, measles, or smallpox, are usually due to staphylococci, streptococci, or other organisms which have gained an entrance through the specific lesions of the mouth, throat, or skin, which characterise these diseases.

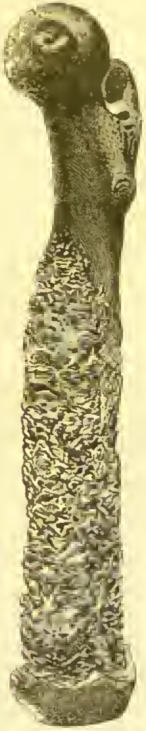

Fig. 185.—New Periosteal Bone on Surface of Femur from Amputation Stump. Osteomyelitis supervened on the amputation and resulted in necrosis at the sawn section of the bone.

(Anatomical Museum of University of Edinburgh.)

Pyogenic Diseases from Direct Infection.—In the diseases of bone considered in the preceding sections, the infection takes place through the arteries. There still remain for discussion those which result from direct infection, through a wound involving the bone—for example compound fractures, gunshot injuries, osteotomies, amputations, resections, or operations for ununited fracture. In all of these the marrow is exposed to infection by such organisms as may be present in the associated wound in the soft parts. In the case of the jaws, the infection may spread to the bone from lesions of the mouth; in the skull, from lesions of the scalp, or of the cranial bones themselves—such as a syphilitic gumma or a sarcoma which has fungated externally; and in the case of the petrous temporal, from suppuration in the middle ear.

The lesions included in this group have become much rarer since the introduction of Listerian surgery. The common lesion is exclusively or mainly an osteomyelitis, which commences and is always most intense at the site first infected—that is, in the marrow exposed in the wound. The marrow presents the changes which characterise ordinary septic or suppurative inflammation. In the case of amputation stumps, fungating granulations may protrude from the sawn end of the bone, and if necrosis takes place, the sequestrum is annular, affecting the cross section of the bone at the saw line, or tubular, extending up the shaft, and tapering off above. The periosteum is more easily detached, is thicker than normal, and is usually actively engaged in forming new bone. In the macerated specimen, the new bone may present a characteristic coral-like appearance, and may be perforated by cloacæ (Fig. 185).

Like other septic infections, it may terminate in pyæmia, as a result of septic phlebitis in the marrow.

The *clinical features* are those of ordinary pyogenic infection; the bone lesion does not impart to these any special character; it may not even be recognised unless the bone affected is exposed to view, either from the nature of the lesion in the soft parts, or when these are opened in the course of an operation. In the case of a stump, healing does not take place until the sequestrum is thrown off or is removed by surgical means. In compound fractures, if one or other of the fragments dies and forms a sequestrum, it is apt to be walled in by new bone, and the sinuses which result may continue to discharge for many years. Even after healing has taken place, the tendency to relapse is a prominent feature of osteomyelitis, especially when associated with compound fractures and gunshot injuries. Months or years afterwards, and either without apparent cause or after some extra strain of the limb or exposure to cold and wet, the bone may become painful and tender, and the soft parts over it inflamed. The symptoms may subside under rest and elevation of the limb and the application of an antiseptic compress, or an abscess may form and burst with comparatively little suffering. The contents may be clear yellow serum or a watery pus—sometimes a small spicule of dead bone may be discharged.

Phosphorus necrosis is the name given to a disease of the jaws met with in those engaged in the manufacture of matches from yellow phosphorus. It will be described along with diseases of the jaws.

TUBERCULOUS DISEASES.

The tuberculous diseases of bones result from infection of the marrow or periosteum by tubercle bacilli conveyed through the arteries. They are characterised by their insidious onset and slow progress, and by the frequency with which they are located in the marrow of the short and flat bones, and in the ends of the long bones. This localisation explains the frequency with which tuberculous disease spreads to adjacent joints. The comparative rarity of lesions in the shafts of the long bones in tuberculosis is in marked contrast to what is met with in pyogenic and syphilitic diseases.

Tuberculous disease of bone is exceedingly rare as a primary affection, the bacilli being usually derived from some pre-existing focus in the body. Tubercle bacilli, like staphylococci, may lie dormant in the marrow for long periods, until, under the influence of such conditions as lowering of the general health or the effects of a comparatively trivial injury, the disease may become active or break out afresh.

Tuberculous Periostitis.—Tuberculous disease may originate in the periosteum or may spread thence from the marrow. It is met with in the ribs, sternum, spinal column, skull, and less frequently in the long bones of the limbs.

In superficial bones, such as the sternum, the formation of tuberculous granulation tissue in the deeper layer of the periosteum, and its subsequent caseation and liquefaction, are attended by the insidious development of a doughy swelling in relation to the bone, which is usually painless although tender on pressure. It is often accidentally discovered by the patient so that its exact date of origin cannot be determined. While the swelling may remain for some time without change, it often increases in size, becomes boggy, fluctuates, and assumes the characters of a cold abscess. The pus perforates the fibrous layer of the periosteum, invading and infecting the overlying soft parts, its spread being influenced by the anatomical arrangement of the tissues. The size of the abscess affords no indication of the extent of the bone lesion from which it originates. The pus gradually reaches the skin, which becomes of a dusky red or livid colour, is thinned out, and finally gives way, the contents of the abscess escaping through a sinus. A probe passed into this sinus strikes the bone, which, from its friable and eroded condition, is described as carious. The sinus persists as long as any active tubercle remains in the tissues, and unless protected by suitable dressings, forms an avenue for infection by pyogenic organisms which favour the spread of the disease both in the bone and in the overlying soft parts. Small superficial sequestra of compact bone may sometimes be found embedded in the granulation tissue formed in relation to the periosteum.

In deeply seated bones, such as the femur, the formation of a cold abscess in the overlying soft parts is often the first evidence of tuberculous disease in the periosteum, and its true source and nature may only be recognised on incising the abscess and exploring its interior with the finger.

Diagnosis.—Before the stage of cold abscess is reached, the localised swelling over the bone is to be differentiated from a syphilitic gumma, from chronic forms of staphylococcal osteomyelitis, from certain forms of enlarged bursa or ganglion, especially those in the region of the knee, from subperiosteal lipoma and from sarcoma. Most difficulty may be met with in relation to periosteal sarcoma, which is characterised, however, by its more rapid and continuous progress, by the severity and persistence of pain in spite of rest, by the absence of suppuration, and of any benefit from treatment. A rise of temperature in the evening is more likely to be present in cases of rapidly growing sarcoma than in tubercle, unless the latter is complicated with pyogenic infection or with phthisis. In difficult cases, recourse should be had to the X-rays and to exploratory incision, and, if necessary, to histological and bacteriological examination of the diseased tissue.

The early recognition of periosteal tuberculosis in the region of the articular ends of long bones is of the utmost importance, as the disease is very liable to spread to the adjacent joint.

Treatment.—When the disease is progressive it is desirable that surgical interference should be had recourse to while the skin is still intact. It may be carried out by the injection of iodoform emulsion, or by open incision and removal of the infected tissues with the sharp spoon. In the case of the ribs it is more satisfactory to remove the whole of the diseased portion of bone. If all the tubercle has been removed and the skin is healthy, the wound may be stitched up with the object of obtaining primary union; if not, the wound is treated by the open method.

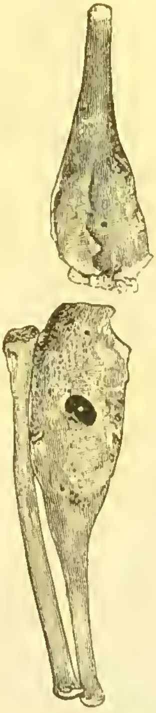

FIG. 186.—Great Enlargement of Lower End of Humerus and Upper End of Ulna, the result of tuberculous osteomyelitis.

(Museum of Royal College of Surgeons, Edinburgh.)

Tuberculous Osteomyelitis.—The majority of tuberculous lesions of the marrow tend to undergo caseation. In rare instances the caseated tissue liquefies and gives rise to a cyst or a cold abscess in the interior of the bone. The area involved by the disease sometimes becomes sclerosed, and may die, leading to the formation of a sequestrum which is denser and heavier than the normal bone, and which separates very slowly. Such sequestra may be concerned in the production of the more serious and persistent forms of tuberculous disease in joints (Fig. 191).

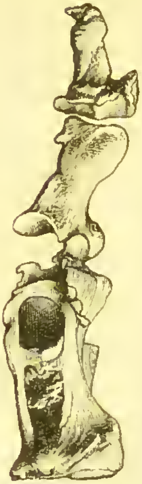

FIG. 187.—The Metatarsal and Phalangeal Bones of a Great Toe, showing destructive changes in tuberculous dactylitis.

(From Mr. Annandale's collection.)

Clinical Features.—It is only in superficially placed bones such as the tibia, ulna, clavicle, lower jaw, or phalanges, that tuberculous disease in the marrow gives rise to signs sufficiently definite to allow of its clinical recognition. In the vertebræ, or in the constituent bones of deeply-seated joints, such as the hip or shoulder, the existence of tuberculous lesions in the marrow may only be inferred from indirect signs—such, for example, as rigidity and curvature in the case of the spine, or from the symptoms of grave and persistent joint-disease in the case of the hip or shoulder. There is evidence to show that tuberculous lesions in the marrow may remain latent for indefinite periods.

With few exceptions, tuberculous disease in the interior of a bone does not reveal its presence, until by extension it reaches one or other of the surfaces of the bone. In the shafts of long bones its eruption on the periosteal surface is usually followed by the formation of a cold abscess in the overlying soft parts. When situated in the articular ends of bones, the disease more often erupts in relation to the reflection of the synovial membrane or directly on the articular surface—in either case giving rise to disease of the joint.

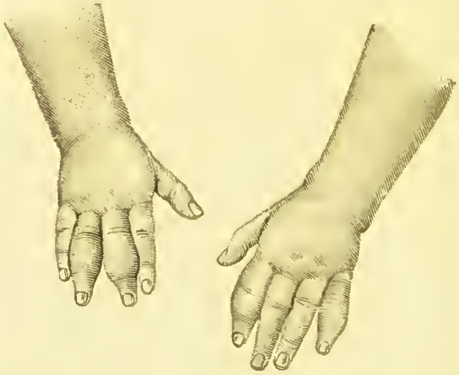

FIG. 188.—Tuberculous Dactylitis.

(Photograph lent by Mr. Stiles.)

Tuberculous dactylitis is the name applied to a diffuse form of tuberculous osteomyelitis of a phalanx, metacarpal or metatarsal bone, the marrow being almost entirely replaced by caseating tuberculous tissue. The macerated bone may present the appearance of having been expanded—the *spina ventosa* of earlier writers; this is due to the absorption of the cortex of the original bone and the continuous formation of new bone by the periosteum. In some cases the shaft of the bone dies, in part or in its entirety, and constitutes a sequestrum.

Although tuberculous dactylitis is essentially a disease of the marrow, there may be at the same time disease in the periosteum. Several phalanges of a finger or toe may be affected simultaneously (Fig. 188).

The *clinical features* are those of a spindle-shaped swelling of a finger or toe, indolent, painless, and interfering but little with its functions. Recovery may eventually occur without suppuration, but in untreated cases it is very common to have the formation of a cold abscess, resulting in one or more sinuses. Previous to abscess formation it may be difficult to differentiate tuberculous dactylitis from the enlargement of the finger in inherited syphilis (syphilitic dactylitis), especially when the tuberculous lesion occurs in a child who is the subject of inherited syphilis. Skiagrams usually show a more abundant formation of new bone in the syphilitic lesion, but in many cases the doubt is only cleared up by observing the progress of the case and the effects of treatment, specific remedies usually bringing about a cure of the syphilitic lesion, while they have no influence in those which are tuberculous.

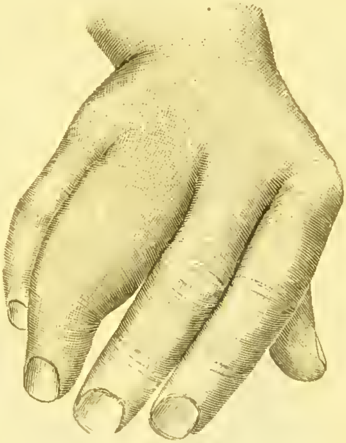

FIG. 189.—Tuberculous Dactylitis.

Treatment is influenced by the knowledge that recovery under conservative measures is by no means uncommon, and that the functional results are usually much better than those following upon operative treatment, although in either case the affected finger is liable to be dwarfed. The finger should be immobilised in a splint, and the general health improved in every possible way. Operative interference is indicated if a cold abscess forms, where there is a persistent sinus, or for the removal of a sequestrum. While amputation may be recommended in the case of toes, it is rarely called for in the fingers unless the disease is threatening to spread up the limb along the lymphatics, or is otherwise endangering the general health. It is more often required in adults than in children.

In the long bones of the limbs tuberculous osteomyelitis is comparatively rare. The pathological and clinical features correspond in the main to those described as occurring in the phalanges. With the exception of the tibia there is often great difficulty in recognising the morbid condition, and in differentiating it from other chronic enlargements of bone, such as pyogenic osteomyelitis, new growths or syphilis. Skiagrams are often of great assistance, especially in children. The nature of the disease may only be recognised on exploring the enlargement of the bone by operation. The treatment consists either in clearing out the disease in the interior of the bone or in resecting the affected bone or portion of bone.

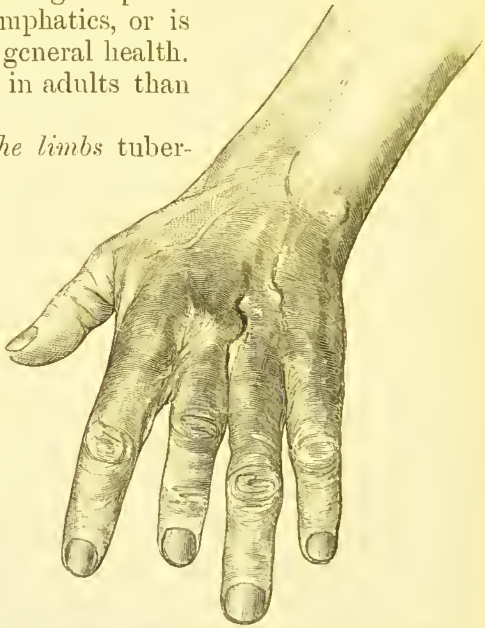

FIG. 190.—Shortening of Middle Finger of Adult, the result of tuberculous dactylitis in childhood.

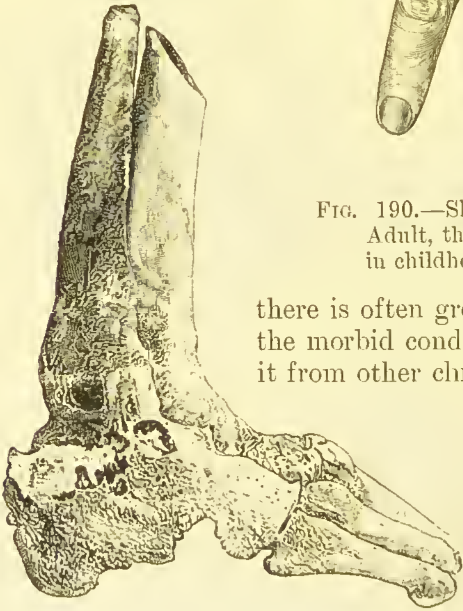

FIG. 191.—Advanced Tuberculous Disease in region of Ankle. The ankle-joint is ankylosed, and there is a large sequestrum in the os calcis.

(Specimen in Anatomical Museum, University of Edinburgh.)

In small cancellous bones such as those of the *tarsus*, diffuse infiltrating tubercle is frequently met with. The clinical features are those of a cold abscess, of disease of the adjacent joint or tendon sheaths. When several bones and joints are simultaneously affected, and there are septic sinuses, amputation is usually indicated, especially in adults. If the disease is less extensive, removal of the diseased bone and other tissues actually infected may suffice. This is oftenest possible in the case of the *os calcis*; satisfactory results are usually obtained even in cases where the whole interior of the bone has to be cleared out with the gouge and sharp spoon. When the disease is confined to one of the other tarsal bones, such as the internal cuniform or cuboid, it may be excised completely, with little or no impairment of the functions of the foot.

Syphilitic Diseases of Bone.

Syphilitic diseases of bone result from infection of the marrow and periosteum by the syphilitic virus conveyed to them through the blood stream. They are met with at any period subsequent to the original contagion. The graver forms are chiefly met with in the tertiary stage of syphilis whether acquired or inherited. The virus is carried to all parts of the skeleton, but the actual development of the disease appears to be influenced by some local predisposition on the part of individual bones, and by external factors such as injury.

Syphilitic diseases of bone are much less frequently met with in practice than those due to pyogenic and tuberculous infections. They show a marked predilection for certain bones, notably the tibia, sternum, and those of the skull. They differ from pyogenic and tuberculous affections in the frequency with which they affect the shafts of long bones rather than the articular ends, and the consequent rarity of joint complications.

In the early stages of acquired syphilis *evanescent periostitis* is met with during the period of the early skin eruptions. The patient complains, especially at night, of pains over the frontal bone, ribs, sternum, tibiæ, and ulnæ. There is localised tenderness elicited on making pressure over the bone, and slight swelling of the periosteum, which rarely amounts to what may be described as a periosteal node. The early superficial lesions usually disappear without leaving any trace of their existence; they may, however, leave localised periosteal thickenings which long remain painful and tender on pressure.

In the later stages of acquired syphilis *gummatous periostitis and osteomyelitis* are occasionally met with. These affections are characterised by the formation of granulation tissue in the periosteum or marrow, either in the form of a circumscribed gumma or of a diffuse gummatous infiltration. The framework of the bone is rarefied in the area immediately involved, and condensed in the parts beyond. If the gummatous tissue degenerates and breaks down, and especially if the overlying skin is perforated and septic infection is superadded, the bone disintegrates and exhibits the condition known as *syphilitic caries;* sometimes the bone dies in visible portions, constituting *syphilitic necrosis.* Syphilitic sequestra are heavier and denser than normal bone, and usually separate very slowly. The bones specially affected by gummatous disease are the skull, the septum of the nose, the nasal bones, palate, femur, tibia, and the bones of the forearm.

In relation to the skull, gummata may form in the pericranium, diploë, or dura mater. Isolated gummata often result in characteristic depressions or in actual perforation of the calvaria. Multiple gummata tend to fuse with each other at their margins, giving the appearance of a combination of circles sometimes surrounding an area of bone in the centre, and cutting it off from its blood-supply (Fig. 192). If the overlying skin is destroyed and septic infection be superadded, such an isolated area of bone is apt to die and furnish a sequestrum; the separation of the dead bone is extremely slow, partly from the want of vascularity in the sclerosed bone round about, and partly from the density of the sequestrum. In exceptional cases the necrosis may involve the entire vertical plate of the frontal bone.

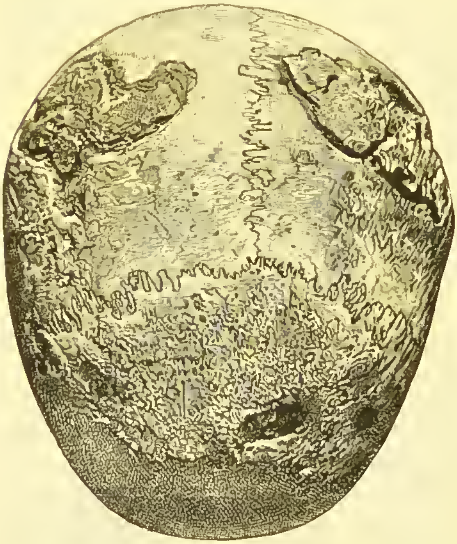

FIG. 192.—Syphilitic Disease of Skull, showing areas of necrosis in process of separation.

(In Mr. Annandale's collection.)

In the septum of the nose, the nasal bones, and the palate, the gummatous granulation tissue infiltrates the periosteum diffusely, eating into the bone with which it is in contact; it then softens and ulcerates on the mucous surface, and so becomes complicated by pyogenic infection. The result is either a crumbling away of the affected bone by caries, or the death of considerable portions which are separated as sequestra, so that unsightly deformity is often produced.

Syphilitic disease of the tibia may be taken as the type of the affection as it occurs in the long bones. Gummatous disease in the periosteum may result in the formation of a well-defined node, or the whole shaft may become the seat of an irregular nodular enlargement, becoming denser and heavier than normal. If a periosteal gumma breaks down and spreads towards the skin, the latter is destroyed, and a syphilitic ulcer with carious bone at the bottom results (Fig. 195). A central gumma may eat away the surrounding bone until it is so weakened that it readily undergoes pathological fracture. In the rare cases in which it attacks the articular ends of the long bones gummatous disease may implicate the adjacent joint and give rise to syphilitic arthritis.

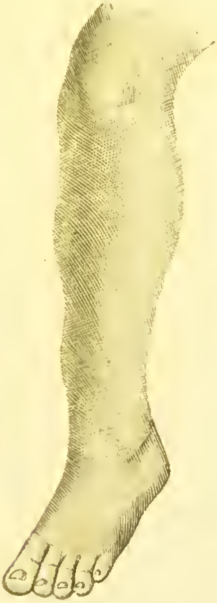

FIG. 193.—Gummatous Disease of Tibia in girl aet. 20, the subject of inherited syphilis.

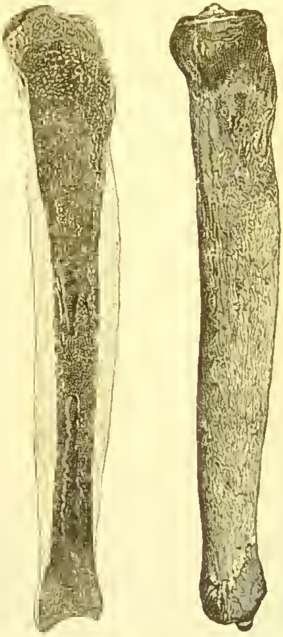

FIG. 194.—Syphilitic Hyperostosis and Sclerosis of Tibia.

Clinical Features of the Bone Lesions in Tertiary Syphilis.—The pains in the bones are much more intense than during the secondary period, and are described as boring—as if a gimlet were being driven into the bone. They are worst at night, sometimes preventing sleep, and have been ascribed to the compression of the nerves as they pass through the sclerosed Haversian canals.

The occurrence of a smooth circumscribed swelling is characteristic of the *periosteal gumma*. The centre is soft and elastic, the margins firm and hard, and they shade off into the surrounding bone. The swelling may disappear entirely, or a densely hard node may remain at the site of the gumma. In other cases the gumma softens in its centre, the skin becomes adherent, thin and red, and finally gives way. The opening in the skin persists as a sinus, or develops into the typical syphilitic ulcer with irregular, crescentic margins; in either case a probe reveals the presence of carious bone or of a sequestrum. The general health may be impaired as a result of superadded pyogenic infection and the absorption of toxins, and waxy degeneration in the viscera may ultimately be induced.

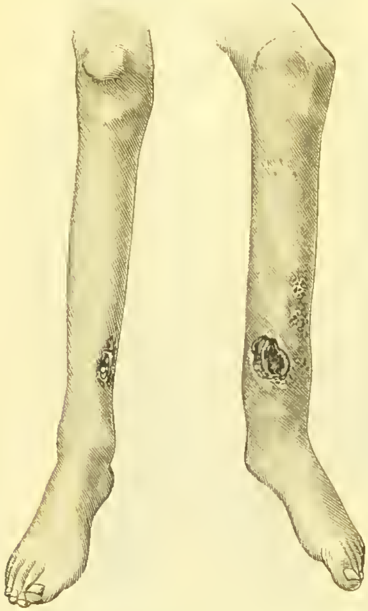

FIG. 195.—Gummatous Disease of Tibiæ in a boy aet. 10, the subject of inherited syphilis.

A *central gumma* in a long bone may not reveal its presence unless it gives rise to pathological fracture, invades an adjacent joint, or erupts through the shell of the bone and reaches the periosteal surface. The X-rays are often useful in the recognition of syphilitic lesions of bones.

In the skull the presence of gummatous disease gives rise to certain special features. Where, for example, there is considerable new formation on the internal surface of the skull there may be pressure on the brain giving rise to headache, Jacksonian epilepsy, or paralysis, according to the seat of the gumma. At the base of the skull it may press upon the cranial nerves, especially at their points of exit, and give rise to symptoms of irritation or paralysis in their areas of distribution. Where a gumma has burst on the skin surface, and there is superadded pyogenic infection, there may not only be persistent sinuses or ulcers with sequestra, but there may be serious intracranial complications of the nature of abscess or meningitis.

In the nose the disease may be characterised by gradually increasing deformity and an offensive discharge ; or by blocking of the tear duct with lachrymal abscess and fistula ; *in the palate* by the formation of perforations and consequent alteration of speech ; *in the wall of the orbit* by exophthalmos and paralysis of the ocular muscles.

Diagnosis.—The conditions most liable to be mistaken for syphilitic disease of bone are chronic staphylococcal osteomyelitis, sarcoma, and tuberculosis. Staphylococcal and tuberculous lesions, in contrast to those of syphilitic origin, are frequently located in the ends of the long bones, are often complicated by disease of the adjacent joint and by the formation of abscess, and are not influenced by anti-syphilitic remedies.

The diagnosis from sarcoma is to be made from the history and progress of the disease, the results of examination with the X-rays, and the effects of specific medicines.

Treatment.—The internal administration of iodides and of mercury, along with the local application of blisters is usually followed by relief of pain and absorption of the gummatous tissue. A periosteal gumma should not be incised, even although it has softened and the skin over it is red. In advanced cases, where the bone has undergone structural alterations of the nature of hyperostosis and sclerosis, or where there are sinuses, suppuration and necrosis, specific remedies may have little effect, or they may only afford relief during their administration, the disease relapsing as soon as they are left off. Great care must be devoted to improving the general health. In cases of persistent or relapsing gummatous disease of the bone with ulceration of the skin over it, in addition to constitutional treatment, it is often necessary to adopt the same surgical methods of treatment as have been recommended in tuberculosis. The diseased soft parts are removed with the spoon and scissors, and the affected bone gouged or chiselled away. Where there is merely hyperostosis and sclerosis of the bone, with severe pain which does not yield to blistering, the thickened periosteum may be incised and the sclerosed bone perforated with a drill, gouge or trephine.

In gummatous disease in the nose or palate, when it is persistent and threatens to result in serious deformity, surgical removal of the affected tissues may be had recourse to. Access may be obtained to the nasal cavities by splitting the nose in the middle line or by raising it up as in Rouge's operation. The infected parts are then removed, the raw tissues swabbed with pure carbolic acid, and after restoring the parts to their normal position the cavity is stuffed with iodoform gauze or worsted.

Lesions of the Bones in Inherited Syphilis.—The bones are more often affected in the inherited than in the acquired disease. The syphilitic lesions met with in infancy—epiphysitis, bossing of the skull, and craniotabes—have been described in the chapter on inherited syphilis.

The lesions of the bones in the later stages correspond to those of the tertiary period of the acquired disease. Inasmuch as they involve bones engaged in active growth, however, and as they occur at the ossifying junctions as well as in the shafts of the bones, they may interfere with the growth of the bones affected. The inherited lesions are not nearly so amenable to the influence of iodides as those of the acquired form. They may persist, or may come and go over periods of many years, with the result that in a long bone, such as the tibia, the external appearances and architectural arrangement may be profoundly altered. The most evident feature may be that the anterior edge of the tibia is flattened, or that the shaft is curved forwards as well as thickened and lengthened, constituting what is known as the "sabre-blade" deformity. There may also be one or more depressed scars adherent to the subjacent bone, resulting from antecedent gummata.

Syphilitic dactylitis is a characteristic lesion which is chiefly met with in children. It is not common in acquired syphilis. It may affect any of the fingers, toes, metacarpals, or metatarsals, but is commonest in the first phalanx of the index finger or thumb. Several fingers and toes may be attacked at the same time or in succession. Anatomically the lesion consists in a gummatous infiltration of the soft parts surrounding the phalanx, or a gummatous osteomyelitis, or in a combination of these.

The segment of finger affected becomes the seat of a swelling which is more evident on the dorsum than on the palm. According to the distribution and extent of the disease the swelling may be acorn-shaped, fusiform, or cylindrical. It is firm and elastic, and but slightly painful or tender. The movements of the finger are impaired, especially if the joints are involved. In its early stages the disease is amenable to anti-syphilitic treatment, and may completely recover.

If untreated, the degenerated gummatous tissue tends to approach the surface, the skin becomes thin and purple, and gives way, often on the lateral aspect of the finger, leaving a sinus. The disintegrated bone may crumble away and escape in the discharge, but the formation of a visible sequestrum is exceptional. Loss of bone may result in shortening and deformity of the finger. The differential diagnosis from tuberculous dactylitis has been described with that disease. Chondroma of the phalanges is recognised by the hardness and definition of the tumour, and by the appearances seen with the X-rays.

The *treatment* of the bone lesions of inherited syphilis is carried out on lines similar to those recommended in the acquired disease. In view of the comparative inefficacy of iodides, most benefit results from improvement of the general health by country or seaside air, by nourishing food, and the administration of cod-liver oil, iron and arsenic. When the gummatous lesions are persistent and destructive it may be necessary to remove the diseased tissues by surgical means.

HYDATID DISEASE OF BONE.

This rare disease in bone has been chiefly studied by Gangolphe in France and by Targett in this country. It results from the lodgment of the embryos of the tænia echinococcus, which are conveyed to the marrow by the blood-stream. In contrast to what is usually observed in hydatids of internal organs such as the liver, the cysts found in bones are extremely small, usually about the size of a pin-head, and they are found in enormous numbers diffusely scattered throughout the marrow. The formation of brood capsules and of scolices is exceptional, and hooklets are rarely found. The parts of the skeleton most often affected are the articular ends of the long bones, and especially the upper end of the tibia, the bodies of the vertebræ, and the bones of the pelvis. The localisation of the parasite frequently appears to be determined by injury.

As the cysts in the marrow increase in number and in size, the framework of the bone is gradually absorbed, and there result excavations or cavities containing the hydatids. The marrow and spongy bone first disappear, after which the compact tissue becomes thin and perforated. The periosteum forms little new bone. The bone gradually becomes expanded and increased in girth, and pathological fracture may result, or the cysts may escape through perforations into the surrounding cellular tissue, and when thus freed from confinement may attain considerable dimensions. Suppuration from superadded pyogenic infection is a frequent complication, and is a serious aggravation of the disease, as it may be attended with extensive necrosis of remaining portions of the framework of the bone, and may lead to infection and disorganisation of the adjacent joint.

The *clinical features* may be so ill-defined that pathological fracture is the first indication of the disease. The patient may complain, over a long period, of deep-seated pains; which, however, are never so severe as in a central abscess of bone. In superficial bones, such as the tibia, there may be some enlargement, and it may be possible to recognise egg-shell crackling, or unequal consistence of the bone, it being hard in some parts, and doughy and elastic in others where the shell has been absorbed. The disease may pursue an indolent course during months or years until some complication occurs, such as fracture or suppuration. The fracture rarely unites, and is therefore usually associated with loss of power and considerable shortening and deformity. On the occurrence of suppuration the disease becomes more active, and abscesses may form in the overlying soft parts and in the adjacent joint. In the vertebral column hydatids give rise to angular deformity and paraplegia. In the pelvis there is usually great enlargement of the bones, and when suppuration occurs it is apt to infect the hip-joint and to terminate fatally. Wherever situated, the disease is very rarely diagnosed before operation, being usually mistaken for central tumour, gumma, tuberculosis, or abscess of bone. Examination with the X-rays is helpful.

The *treatment* consists in thorough eradication of the parasite by operation. The bone is laid open and scraped or resected according to the extent of the disease. In advanced cases, complicated with spontaneous fracture and with suppuration, amputation affords the best chance of recovery.

The lesions in the bones resulting from *actinomycosis* and from *mycetoma* have been sufficiently described with these diseases.

TROPHIC DISEASES OF BONE.

These include rickets, scurvy-rickets, osteomalacia, osteitis deformans, fragilitas ossium, and certain lesions met with in diseases of the nervous system.

Rickets.

Rickets or rachitis is a constitutional disease associated with disturbance of the nutrition, and attended with characteristic changes in the skeleton. The disease is most common and most severe among the children of the poorer classes in large cities, who are improperly fed and are brought up in unhealthy surroundings. There is evidence to show that the most important factor in the causation of rickets is the administration of food deficient in animal fat, proteids, and salts of lime, or which contains these in such a form that they are not readily assimilated. The occurrence of the disease is rendered more likely and its features are exaggerated by imperfect oxygenation of the blood as the result of a deficiency of fresh air and sunlight, and by other conditions which tend to lower the general health.

Pathological Anatomy.—The bone lesions are of considerable surgical importance. The most striking feature is the softness (malacia) of the bones due to the excessive absorption of osseous tissue and the formation of an imperfectly calcified tissue at the various sites of ossification. The affected portions of the skeleton lose their rigidity, so that the bones bend under the weight of the body, the traction of muscles, and from the influence of other mechanical forces. When the disease is recovered from, a process of repair sets in which often results in the affected bones becoming denser and heavier than normal.

The periosteum is abnormally thick and vascular, and when detached carries with it plates and spicules of soft porous bone. The new bone deposited by the periosteum may be so abundant that it forms a thick crust on the surface, and in the flat bones of the skull this may be heaped up in the form of bosses or ridges resembling those met with in inherited syphilis.

In the epiphysial cartilages and at the ossifying junctions all the processes concerned in ossification, excepting the deposition of lime salts, occur to an exaggerated degree. The cartilage of the epiphysial disc proliferates actively and irregularly so that it becomes softer, thicker, and wider, and gives rise to a visible swelling, best seen at the lower end of the radius and lower end of the tibia, and at the costo-chondral junctions, where the series of beaded swellings is known as the "rickety rosary."

The zone of endo-chondral ossification is increased in depth; the marrow is abnormally vascular; the normal arrangement of the tissue elements concerned in the formation of bone is markedly disturbed, and any new bone which is formed is imperfectly calcified. The result is that the affected bones may never attain their normal length, and they remain stunted throughout life as in rickety dwarfs (Fig. 196), or the shafts of the long bones may grow unequally and come to deviate from their normal axes, as in knock-knee and bow-knee. Areas of overgrown cartilage may persist as islands surrounded by bone or marrow, and, according to Virchow, may subsequently become the starting-point of cartilaginous tumours.

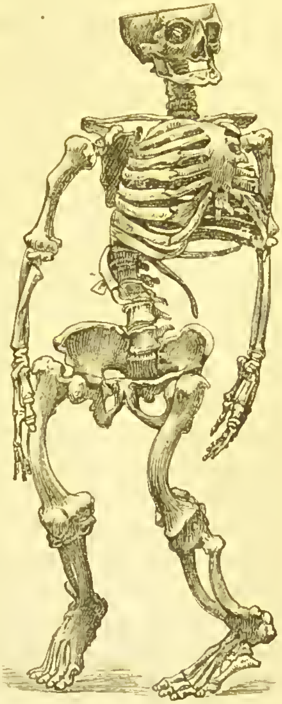

Fig. 196.—Skeleton of Rickety Dwarf. The skeleton is that of "Bowed Joseph," leader of the meal riots in Edinburgh, who died in 1780.

(Anatomical Museum, University of Edinburgh.)

The changes in the marrow consist chiefly in an exaggeration of the normal process of absorption of bone. In the shafts of the long bones the cortex becomes porous and yielding, and the spongy bone is rarefied or disappears; hence the bones readily bend or break under mechanical influences. In the flat bones of the skull the absorption may result in the entire disappearance of areas of bone, leaving a thin membrane which dimples like thin cardboard under the pressure of the finger—a condition known as craniotabes.

Changes in the Skeleton as a Whole.—The distribution and nature of the changes in the skeleton vary widely in different cases, being influenced by the period of onset, the severity and duration of the disease, and the conditions under which the child is placed.

In Young Children before they are able to walk.—The fontanelles and sutures remain open until the end of the second year or longer and the frontal and parietal eminences are prominent. While craniotabes is present in some cases, in others there is great thickening of the bones. If there is hydrocephalus the head is unduly large. The jaws are altered so that while the upper jaw is contracted into the shape of a V, the lower jaw is square instead of rounded, and when the teeth erupt they do not oppose one another. In the thorax the chief feature may be the beading at the costo-chondral junctions, especially of the fifth and sixth ribs, or its walls may be contracted, especially if the respiration is interfered with as a result of bronchial catarrh or adenoids. The contraction may take the form of a vertical groove on each side, or of a horizontal groove at the level of the upper end of the xiphisternum; when the sternum and cartilages are pushed forwards and project in front the deformity is known as "the pigeon-breast."

The spine may be curved backwards or to one or other side; the backward curve or *kyphosis* being met with in infants who sit up, the lateral curvature or *scoliosis* in those who persistently lie, or are carried, on one side.

In the limbs the prominent features are the deficient growth in length of the long bones, the enlargements at the epiphysial junctions, and the bending and occasional greenstick fracture of the shafts. At this stage the curves depend on the attitude of the child while sitting or being carried—for example, the arm bones become bent in children who paddle about the floor with the aid of their arms; while in a child who lies on its back with the lower limbs everted, the weight of the limb may lead to curvature of the neck of the femur—coxa vara. The clavicle or humerus may sustain greenstick fracture from the child being lifted by the arms, the femur by its falling on the ground. From the extreme laxity of the ligaments the joints are often abnormally mobile and the limbs may be twisted about in abnormal directions, and the knee may be hyperextended (*genu recurvatum*).

In Older Children who are able to walk.—The most important deformities met with at this age occur in the spine, pelvis, and lower extremities, and result from arrest of growth and from yielding of the softened bones under the weight of the body. Scoliosis is the usual type of spinal curvature, and in extreme cases may lead to a pronounced form of hump-back. The pelvis may simply remain small, or it may be contracted or flattened in the sagittal plane; when the bones are unusually soft the acetabular portions are pushed inwards and the pelvis assumes the shape of a trefoil, as in the malacia of adult women. In the lower extremities the shaft of the femur is curved forwards and outwards, the bones of the leg outwards as in bow-leg, or forwards, or forwards and outwards just above the ankle. The deformities at the knee (genu valgum and genu varum) and at the hip (coxa vara) will be described with deformities.

Clinical Features.—Although rickets may be met with at or soon after birth, it is usually not until the child is three or four months old that the disease manifests itself, and sometimes not until the second year. The mother notices that the child perspires excessively during sleep, especially about the head, it is restless and throws off the clothes, is disinclined to be moved, and cries unless very gently handled. Its muscles become soft and flabby, and it is liable to attacks of diarrhœa and of bronchial catarrh. Dentition is delayed, and the teeth are apt to appear in the wrong order. The child is late in learning to walk, and easily unlearns it. On examination there is no difficulty in recognising the changes in the skeleton which have been already described. The cranium is most often affected in young infants, the spine, thorax, and arms in those a little older, and the lower extremities in children in whom the disease has developed comparatively late. The abdomen is prominent, partly from flatulent distension of the bowels, partly from downward displacement of the liver which is sometimes enlarged, and from weakness of the belly walls; it appears larger from contrast with the contracted chest. The spleen may be enlarged. The weakness of the muscles of the trunk and limbs may be so pronounced as to excite the suspicion of a lesion of the spinal cord; and there may be an increased excitability of the central nervous system, shown by the occurrence of laryngismus stridulus or of general convulsions.

Rickety children present little resistance to infective diseases, and readily succumb, especially to pulmonary and intestinal tuberculosis. The progress of the disease is slow and intermittent, and varies with the age of the child, its surroundings, and the treatment employed; it may pass off in a few weeks, or may drag on for months or even years. The majority of rickety patients seen in surgical wards suffer rather from the deformities resulting from rickets than from the disease itself.

The examination of a large series of children at different ages shows that rickety deformities become less and less frequent with each year. Those who recover may ultimately show no traces of rickets, and this is especially true of children who grow at the average rate; in those, however, in whom growth is retarded, especially from the fifth to the seventh year, the deformities are apt to persist and become permanent. It may be noted that scoliosis of rickety origin has little tendency towards spontaneous recovery.

Treatment.—The essentials in treatment consist in regulating the diet, improving the surroundings of the patient, and preventing deformity. In the first instance it may be necessary to attend to the stomach and bowels. Fresh air and sunshine are recommended, with precautions against catching cold. A change to the seaside, and the use of salt-water baths, followed by massage, are of great value. Phosphorus in doses of 100th grain may be given dissolved in cod-liver oil, and preparations of iron and lime may be added with advantage. In order to avoid those postures which predispose to deformities the child should lie on its back as much as possible. In the well-to-do classes this is readily achieved with the assistance of a nurse and perambulator. In hospital out-patients the child is kept off its feet by the use of a light wooden splint applied to the outer aspect of each lower extremity and extending from the pelvis to six inches beyond the sole. Splints and apparatus which allow the child to walk are not to be recommended.

When deformities have already taken place, the treatment depends upon whether or not there is any prospect of spontaneous recovery. Under five years of age recovery may be confidently expected. The child should be kept off its feet, and the limbs bathed and massaged. In children of five or six and upwards the prospect of natural recovery is a diminishing one, and the more satisfactory means of correcting the deformity is by operation. In rickety curvature of the spine, the child should lie on its back on a firm mattress, and the muscles acting on the trunk should be braced up by massage and appropriate exercises.

Late Rickets, Malacia of Puberty, Rachitis Adolescentium.—Under this head are included conditions which are essentially the same as those already described, only the disease is not attended with any disturbance of the general health, and is more local, the pathological changes being confined to the ossifying junctions, specially affecting those which are most active during adolescence—for example, at the knee-joint. It is met with at any age from nine to seventeen, and is generally believed to be due to a recrudescence of rickets which had been present in early childhood. It may play an important part in the production of certain deformities which occur at or near puberty,—especially genu valgum, genu varum, and coxa vara,—and it may be indirectly concerned in the production of such deformities as scoliosis and flat foot.

Scurvy-Rickets, Hæmorrhagic Rickets.—This disease, described by Barlow and Cheadle, is usually regarded as a combination of scurvy and rickets, although, according to Ashby, the hæmorrhagic element in the disease is the result of anæmia. It is met with in infants under two years who have been brought up upon sterilised or condensed milk and other proprietary foods, and chiefly in the well-to-do classes. It is characterised by anæmia, severe pains in the bones, and by the occurrence of fractures and separation of epiphyses attended with sub-periosteal hæmorrhage, chiefly in relation to the bones of the thigh or leg. When a fracture takes place the infant ceases to move the limb and screams if it is touched, and an excessively tender swelling may be recognised in the region of the epiphysial junction or adjacent shaft. The skin becomes tense and shiny, and there may be crepitus. As in ordinary scurvy, there may be extravasations of blood in relation to the muscles and the skin, appearing on the surface as bruises. The disease may simulate one or other of the pyogenic bone affections or a sub-periosteal fracture of traumatic origin.

The *treatment* consists in correcting the errors in diet. The infant should have a wet nurse or a plentiful supply of cow's milk in its natural state. Anti-scorbutics may be given in the form of orange, lemon, or grape juice, and of potatoes bruised down in the milk. Under this treatment a marked improvement usually takes place within a few days, the hæmorrhages cease, and the extravasated blood is gradually reabsorbed. The further treatment is that of rickets.

Osteomalacia.—The term osteomalacia is used to include a group of conditions in which the bones become soft and yielding, so that they are unduly liable to bend or break. That form which is associated with rickets has already been described.

The osteomalacia of pregnant and puerperal women is the commonest and best known member of this group. It is chiefly met with in women of the poorer classes who bear children under unhealthy conditions. It is more common in those parts of South Germany bordering on the Rhine, and in certain parts of Italy, than in this country. While it may occur during a first pregnancy, it is chiefly met with in multiparous women. It is usually confined to the pelvis and lumbar vertebræ, but in extreme instances may involve the entire skeleton.

The essential feature is the absorption of lime salts from the affected bones; the bone matrix, thus decalcified, disappears in its turn, so that the bones may be broken, bent or indented, or pulled out at the attachments of muscles. After death they may be cut with a knife or squeezed like a sponge. In the progressive stage of the disease the marrow becomes very vascular, loses its fat, and is converted into a gelatinous tissue variously coloured with blood pigment; hæmorrhages into the marrow are responsible for the pigmentation, and for the presence of ill-defined cysts filled with brown or yellow fluid. In extreme cases the shafts of the long bones come to resemble membranous tubes which may be bent or twisted in any direction.

Clinically, the condition may not be recognised until the pelvis is found to be contracted when it is examined in relation to pregnancy or child-birth. As a rule, however, the patient complains of shooting pains in the lower part of the back, weakness of the lower limbs, and of being unable to sit. The bones may be tender on pressure, and the knee jerks are usually increased. When the spinal column is affected the patient may lose a foot or more in height within a few weeks. There may be a peculiar waddling gait from curving of the neck of the femur on both sides, and inability to flex the thigh and lift the foot from the ground. The gross changes in the skeleton vary with the stage and extent of the disease, and with the habits and attitudes of the patient, and need not be described in detail. The student is referred to text-books on midwifery for a description of the important changes which take place in the pelvis. If recovery ensues, abundant new bone is formed in place of that which has been lost, the bones regain their rigidity, and the existing deformities become permanent. The disease, however, may last for years, or may break out afresh with later pregnancies. The patient may become a helpless cripple, confined to bed and liable to succumb to intercurrent complications or to the results of difficult child-birth. The diagnosis is only difficult in the early stage of mild cases, in which the marked weakness of the lower extremities and exaggeration of the knee jerks may suggest a resemblance to certain lesions of the spinal cord. Careful measurement should be made of the stature and of the diameters of the pelvis. In well-developed cases the bones do not give the usual shadow when examined with the Röntgen rays.

The cause of the disease is unknown; it has been suggested that it is the result of an affection of the central nervous system, probably beginning in the nerve cells of the anterior cornua of the cord.

Treatment.—Measures directed towards improving the general health should be persevered with. The administration of phosphorus dissolved in cod-liver oil is generally recommended. Removal of the ovaries, as suggested by Fehling in 1886, is usually followed by the relief of symptoms and arrest of the progress of the disease, and should therefore be had recourse to when other treatment has failed.

Neuropathic Forms of Osteomalacia.—In certain chronic diseases of the brain or cord, changes in the skeleton of the nature of osteomalacia may be met with. It is at present unknown why in certain cases the bones may lose their lime salts and bend, while in others they become porous and brittle. The senile form of osteomalacia is apparently also of nerve origin.

Osteomalacia associated with New Growths in the Skeleton.—Recklinghausen and others have described cases in which the marrow is transformed into a white fibrous tissue which may be the seat of hæmorrhages and cysts along with the development of giant-celled tumours or myelomata scattered throughout the skeleton. This condition is usually associated with multiple fractures. There is also a form of osteomalacia associated with secondary cancer when this is widely diffused throughout the skeleton.

Osteitis Deformans—Paget's Disease of Bone.—This rare and interesting disease was first described by Sir James Paget in 1877. The changes in the bones are regarded as partaking of the characters of a chronic inflammation whereby the marrow is transformed into a vascular connective tissue; its bone-eating functions are exaggerated, and the framework of the bone becomes rarefied, so that it bends under pressure. This element of the disease suggests a resemblance to the lesions described under the head of osteomalacia. In the course of time new bone is formed in great abundance both by the periosteum and the marrow; it is at first devoid of lime salts, but later becomes calcified, so that the bones regain their normal rigidity. The formation of new bone is, however, much in excess of the normal, the bones become large and bulky, their surfaces rough and uneven, their texture sclerosed in parts, and the medullary canal in the long bones is frequently obliterated. The curving of the long bones, which is such a striking feature of the disease, may be associated with actual lengthening, and the changes are usually remarkably symmetrical (Fig. 198). The bones forming the cranium may be enormously thickened, the distinction into tables and diploë is lost, and, while the general texture is finely porous, there may be areas of bone as dense as ivory (Fig. 197).

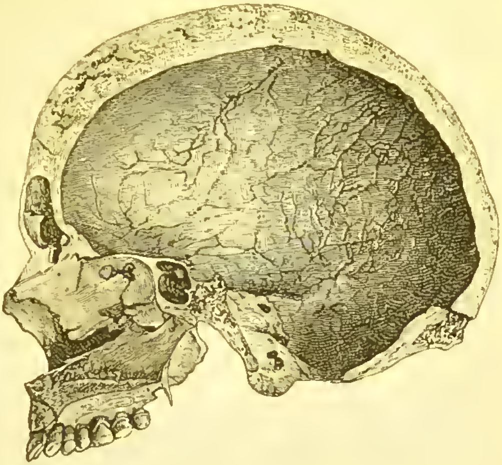

Fig. 197.—Changes in Skull resulting from Osteitis Deformans.

(Anatomical Museum, University of Edinburgh.)

Clinical Features.—The disease affects individuals of either sex over fifty years of age, and develops very gradually without any discoverable cause. The patient's attention may be first attracted by the occurrence of vague pains in the back or limbs, or by the obvious enlargement and bending of such bones as the tibia or femur, or by the gradual increase in size of the head, necessitating the wearing of larger and larger hats. When the condition is fully developed the attitude and general appearance are eminently characteristic. The height is diminished, and the arms appear unnaturally long as a result of the curving of the spine and lower limbs; the shoulders are rounded and the head bent forwards;

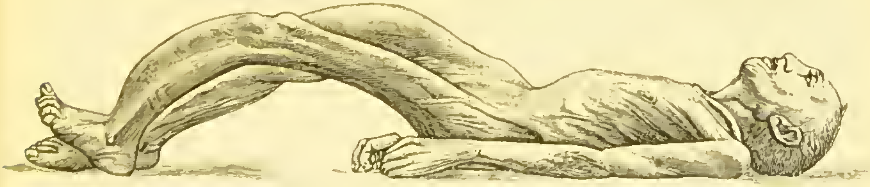

Fig. 198.—Alterations in Lower Limbs resulting from Osteitis Deformans.

the legs are held apart, slightly flexed at the knee, and are rotated out as well as curved ; the whole appearance is that of the larger anthropoid apes, but is relieved by the wide and arched forehead. The patient may be able to walk and ride on horseback, although he may complain of the weight of his limbs, and of difficulty in breathing owing to the fixation of the chest. There are no mental symptoms. The muscles of the limbs may waste to such an extent as to leave the large, curved, misshapen bones covered only by the skin (Fig. 198).

The disease is of indefinite duration, the general health remaining for long unaffected ; the patient may, however, become bedridden, and finally succumb to bronchitis or other intercurrent disease. In a considerable number of cases the bones become the seat of sarcoma, either solitary or multiple, and may then sustain pathological fracture.

There is no *treatment* beyond that directed towards the relief of symptoms.

Neuropathic Atrophy of Bone.—The conditions included under this head occur in association with diseases of the nervous system. There is general agreement that the nutrition of bones is under the influence of trophic nerves, although this influence is neither so direct nor so specialised as is the case in muscles and secreting glands. It is difficult to ascertain how far the changes in the skeleton associated with nerve lesions are the result of altered trophic nerve influence, and how far they are the result of vasomotor disturbances.

Among the clinical forms of neuropathic atrophy, most importance is attached to the acquired fragility of the bones met with in *locomotor ataxia* and other chronic diseases of the spinal cord. The bones become porous and brittle, with an excess of fatty marrow, so that they are liable to be fractured by forces which would be insufficient to break a healthy bone. The fragility especially affects the bones of the extremities, and may occur before there are any definite nerve symptoms, but they are more often met with in the stage of ataxic movements, which, from their abruptness and want of control, may play a considerable part in the causation of the fractures. Joint lesions of the nature of Charcot's disease may exist simultaneously with the alterations in the bones. The fractures may be unattended with pain, and they may fail to unite ; when repair does take place it is sometimes attended with an excessive formation of callus. In *syringomyelia* pathological fracture is not so frequent as in locomotor ataxia ; it is more likely to occur in the bones of the upper extremity, and especially in the humerus, as a result of muscular action.

In paralytic dementia and other *chronic forms of insanity* a similar porosity and brittleness of bones may be observed, and may result in pathological fracture, especially of the ribs or femur. The occurrence of these fractures in the insane may lead to unjust reflections on the conduct of those in charge of the patient. In some cases of epilepsy the bones may be so brittle that the patient sustains a fracture at every seizure in which he falls to the ground, and the fracture may show a remarkable degree of comminution.

Fragilitas Ossium.—This heading is merely used for convenience to include conditions in which there is an undue fragility of the bones without there being any disease to account for it. This may occur in several members of the same family, or there may be no such history of heredity. The bones are easily fractured, and as a rule unite normally ; but in some cases union is much delayed, and is associated with great deformity. The fractures may occur before birth, or at any period of extra-uterine life.

TUMOURS OF BONE.

Primary tumours of bone grow from the marrow, the periosteum, or, in the case of young bones, from cartilage. They are all of the connective-tissue group, and include the varieties known as fibroma, myxoma, lipoma, chondroma, osteoma, myeloma, and sarcoma. *Secondary tumours* are those which occur in bone, either as a result of metastasis from other parts or by direct spread from adjacent tissues. They are divided according to their seat into periosteal and medullary.

Periosteal tumours are usually situated on one side of the bone in the first instance, but they may come to surround it completely. They are bounded externally by the fibrous layer of the periosteum, which is, however, infiltrated and perforated in the case of malignant tumours.

Central or medullary tumours usually lead to absorption of the bone in immediate relation to them, while new bone is laid down externally. The bone as a whole may be greatly increased in girth as a result of these processes, and is often described as having been "expanded" by the growth in its interior. Whether or not a central tumour invades the investing soft parts depends on the rapidity of the growth of the tumour on the one hand, and on the activity of the periosteum in forming new bone on the other.

Primary tumours of bone are usually solitary, but the chondroma, osteoma, myeloma, and sarcoma may be multiple from the outset.

It is frequently observed that tumours of bone follow upon injury. The connection between the injury and the development of the tumour is not established, but it is quite possible that the trauma merely hastens the growth of an already existing tumour, or, on the other hand, it may excite growth in embryonic residues which have resulted from some irregularity in development.

Primary Tumours—Osteoma.—This tumour is called an *exostosis* when it projects from the surface of a bone. Those derived directly from the tissues of the periosteum may be described as *membranous exostoses*—for example, those of the skull, which are usually dense and compact like ivory; hence the term ivory exostosis. When derived from hyaline cartilage—for example, those at the ends of the long bones of the limbs—they are known as *cartilaginous exostoses.* These are invested with a layer or cap of cartilage from which they may continue to grow until the skeleton attains maturity. Because of their spongy structure they are also described as *cancellous or spongy exostoses.*

Exostoses are usually rounded or mushroom-shaped tumours of limited size; they may be either sessile or pedunculated, and their free surface may be smooth or nodulated. Cartilaginous exostoses in the vicinity of joints may be invested with a synovial sac or bursa—the so-called *exostosis bursata.* The bursa may be derived from the synovial membrane of the adjacent joint with which its cavity sometimes communicates, or it may be of adventitious origin. When such a bursa is distended with fluid it may prevent the recognition of the underlying exostosis.

Clinically, the osteoma is met with as a hard, indolent tumour growing from a bone. It is usually discovered accidentally, unless it presses injuriously on adjacent structures. Its special features vary with its situation. In the orbit it displaces the eyeball; in the nasal fossæ and in the external auditory meatus it causes obstruction, which may be attended with ulceration and discharge; in the vicinity of a joint it may interfere with movement; on the inner side of the knee it may prevent grasping of the saddle in riding. When growing from the dorsal aspect of the terminal phalanx of the great toe—a common situation—it displaces the nail and may project through its matrix at the top of the toe, while the soft parts over it may be ulcerated from pressure. When it presses on the nerves of a limb it causes pains, cramps, and other nerve symptoms.

The diagnosis of osteoma is to be made from its long duration and slow growth, its situation, its hardness, and by the shadow which it presents when examined with the X-rays.

Treatment.—An osteoma which does not cause symptoms may be left alone. If causing symptoms, they are removed by dividing the neck or base of the tumour with a strong chisel, care being taken to remove the whole of the overlying cartilage. The dense varieties met with in the bones of the skull present greater difficulties; if it is necessary to remove them, the base or neck of the tumour is perforated in many directions with highly tempered drills rotated by some form of mechanical engine, the division of the bone being completed with the chisel.

The *multiple exostoses* met with in childhood and youth are ossified chondromata. They are of congenital origin and are often inherited. They may interfere with the growth of the skeleton as a whole, or with that of the bone affected; they themselves usually cease growing when the skeleton reaches maturity. They are chiefly met with at the ends of the long bones which possess the most active epiphyses—that is, in the region of the knee and at the shoulder and wrist. When they originate from the ossifying junction of a long bone they may migrate along the shaft as the latter increases in length. They may also grow from flat bones, such as the scapula and pelvis. They are often symmetrical, and vary in size from a hazel-nut to a fœtal head.

Diffuse Osteoma, Leontiasis Ossea.—This rare disease was described by Virchow, and named leontiasis ossea because of the peculiar disfigurement. It usually commences in young adults, who are otherwise in good health, as a diffuse overgrowth of the upper jaws. These bones are enlarged in all directions and project as prominent bosses on the face, and the nasal fossæ, maxillary and frontal sinuses become filled up with bone, which also encroaches on the orbital cavities. In addition to the hideous deformity the patient may complain of blocking of the nose, loss of smell, and protrusion of the eyes, sometimes resulting in blindness. The malar and frontal bones are usually involved, and in extreme cases the diffuse overgrowth may spread to the entire vault of the skull and to the lower jaw. The base of the skull is usually exempt. The disease is of very slow progress and may become arrested; life may be prolonged for many years, or may be terminated by brain troubles or other intercurrent affections. In certain cases it may be possible to remove some of the more aggressive of the bony masses. A remarkable form of unilateral hypertrophy and diffuse osteoma of the skull has been observed by Jonathan Hutchinson and Alexis Thomson following very accurately the distribution of the fifth nerve on one side.

Chondroma.—Cartilaginous tumours grow from the shafts of the long bones, or from the scapula, ilium, ribs, or jaws. They usually project from the periosteal surface of the bone, and may attain an enormous size. Or they may grow in the interior of a bone, the so-called enchondroma.

The cartilage composing the tumour frequently undergoes myxomatous degeneration, resulting in softening of the cartilage into a glairy, semifluid jelly, and if this change takes place throughout the tumour it may present the appearances of a cyst. On the other hand, the cartilage may become harder from calcification or conversion into bone. The most important transition of all is that into sarcoma, the so-called *malignant chondroma* or chondro-sarcoma; it is associated with the acquisition of greater vegetative activity, so that it may recur on removal, and parts of it may be carried off in the blood-stream and give rise to secondary growths, especially in the lungs.

Clinically, the chondroma is met with as a slowly growing tumour, nodulated or bossed on the surface. It is especially common in the bones of the hand, often in a multiple form (Fig. 199). Its surface may be smooth or lobulated. Its consistence may be dense and elastic like normal cartilage, or it may present areas of softening or of bony hardness. The soft parts move freely over it, except in relation to the bones of the fingers, where the skin may become adherent and ulcerate, and suggest a malignancy which does not exist. In more deeply seated bones the chondroma is not recognised so easily, and may be confused with sarcoma. Large tumours growing from the bones of the extremities may implicate the main vessels and nerves (Fig. 200), either simply surrounding them, or pressing on them injuriously so as to cause symptoms; they may also interfere with the movement of joints.

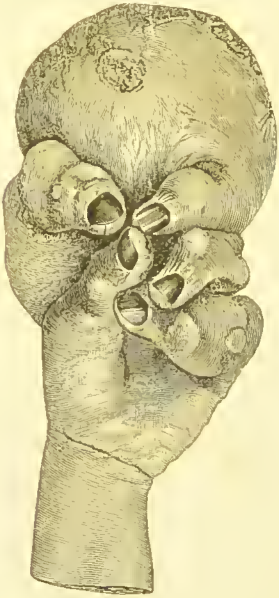

Fig. 199.—Multiple Chondromata of Bones of Hand.

(Anatomical Museum, University of Edinburgh.)

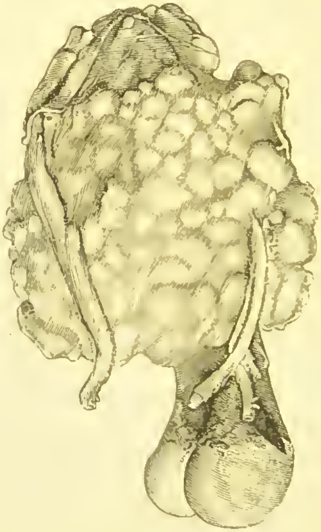

Fig. 200. — Chondroma of Femur. The femoral vessels pass through the substance of the tumour, and the sciatic nerve is adherent to its surface.

The prognosis varies with the type of tumour: if innocent they grow very slowly, and may even become stationary. Rapid growth is an indication of malignancy.

In the treatment of chondromata it is necessary to remove the whole tumour, even although it appears to be innocent, and in periosteal growths, especially if they are pedunculated, this is comparatively easy. When an entire bone, such as the scapula or lower jaw, is involved, it is better to remove the bone or the greater part of it. In the case of central tumours the external shell of bone is to be removed over an area sufficient to allow of the enucleation of the tumour in the interior. It is sometimes better to resect the affected portion of bone, or have recourse to amputation, especially in the case of the fingers. Should there be any evidence of malignancy, early and high amputation is the procedure recommended.

The chondromata met with at the ends of the long bones of the limbs, and which undergo ossification concurrently with the skeleton, have been described with the osteomata.

Fibroma is chiefly met with as a periosteal growth from the bones in relation to the mouth and pharynx, the simple epulis of the alveolar margin and the naso-pharyngeal polypus being well-known examples. They may be vascular and cellular, showing all transitions to sarcoma; or they may be fibrous and undergo partial conversion into bone. Their diagnosis and treatment belong to the special regions in which they are met with.

Myxoma, *lipoma*, and *angioma* of bone are all very rare. They may be periosteal or central. Their exact nature is seldom recognised until they are subjected to operative interference.

The **myeloma** or **myeloid tumour** was formerly classified with the sarcomata. Large giant cells, like those normally present in the marrow, form the chief elements of the tumour. These tumours usually present a brownish-red or chocolate colour, and on account of their vascularity are liable to hæmorrhages, to pigmentation, and to the formation of blood cysts. Sometimes the arterial vessels are so dilated as to impart to the tumour an aneurysmal pulsation and bruit. The enlargement or "expansion" of the bone may result in the cortex being represented by a thin shell of bone, which may crackle on pressure. The tumour tissue in the interior may liquefy so as to form a single or a multilocular cyst. The myeloma is most often met with in adolescents in the bones in the region of the knee (Fig. 201); it grows slowly, without much pain, and may even become quiescent; it may be mistaken for disease in the knee-joint, or, if it pulsates, for popliteal aneurysm. Although occasionally capable of giving rise to secondary growths presenting a similar giant-celled structure, these tumours are, as a rule, innocent, and should be treated as such, either by shelling out the new growth from the marrow, or by resecting the portion of bone in which the tumour is lodged.

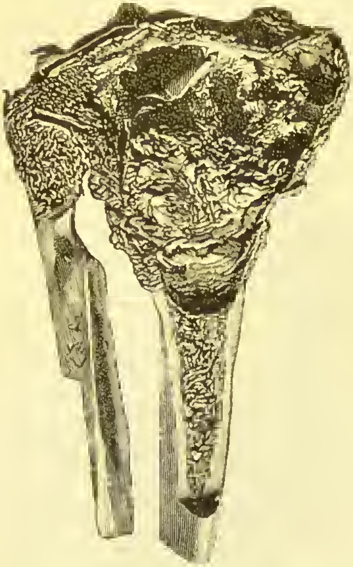

FIG. 201.—Myeloma of Head of Tibia. The patient had formerly sustained a fracture of the fibula.

(Museum of Royal College of Surgeons, Edinburgh.)

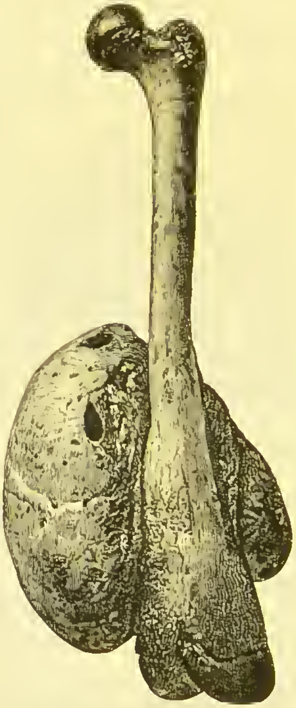

FIG. 202.—The Femur of a boy æt. 12, showing the Bony Shell of a large Cyst-like Cavity which communicates with the interior of the bone. The original tumour was probably a sarcoma.

(The specimen, which is in the Anatomical Museum, University of Edinburgh, is figured in Syme's *Principles of Surgery*.)

The myeloid tumours of the jaw will be described with the diseases of the jaws.

The **sarcomata** are the commonest tumours of bone, and present wide variations in structure and in clinical features. Structurally, two main groups may be differentiated: the soft, rapidly-growing cellular tumours, and those which are characterised by the formation of fully formed fibrous tissue, cartilage or bone.

The *soft cellular tumours* are mainly composed of spindle or round cells; they grow chiefly from the marrow of the spongy ends of the long bones, the diploë of the skull, the pelvis, vertebræ, and jaws. In the process of growth they may cause little alteration in the contour of the bone, but eat away its framework, and replace it, so that the continuity of the bone is interrupted by tumour tissue, and pathological fracture is a very frequent result. The small round-celled sarcomata are among the most malignant tumours of bone, growing with great rapidity, and giving rise to secondary growths at a very early stage.

The second group includes the fibro-, osteo-, and chondrosarcomata, and combinations of these, in all of which fully formed tissue predominates over the cellular elements of the growth. They grow chiefly from the deeper layer of the periosteum, and project in the first instance from the surface, but later tend to surround the bone (Figs. 203 and 205). They also invade the interior of the bone from which they are growing, filling up the marrow spaces with a white, bone-like substance, and in the case of the flat bones of the skull may traverse the diploë and erupt on the inner table. The tumour tissue nearest the bone forms a dense, white, structureless basis, from which

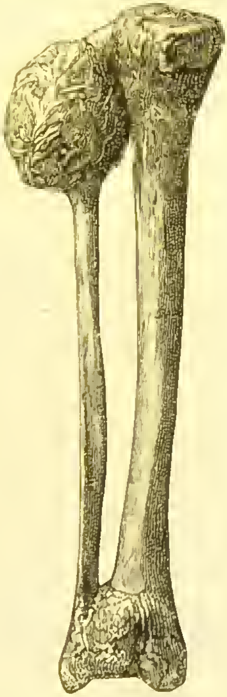

FIG. 203.—Periosteal Sarcoma of Head of Fibula, from child æt. 8.

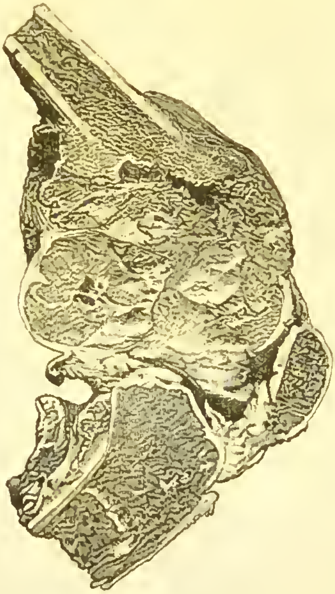

FIG. 204.—Central Sarcoma of Lower End of Femur, invading the knee-joint.

(Museum of Royal College of Surgeons, Edinburgh.)

there radiate into the outer softer parts of the tumour, spicules, needles and plates of a similar bone-like material. The peripheral portion consists of softer sarcomatous tissue, which invades the overlying soft parts; the articular cartilage long resists destruction, and pathological fracture is exceptional. Secondary growths are chiefly met with in the lungs, the metastasis taking place through the veins. These ossifying sarcomata are most often met with in the femur and tibia, less frequently in the humerus, skull, pelvis, and jaws. In the long bones they may grow from the shaft, while the chondro-sarcomata more often originate in the extremities. Sometimes they are multiple, several tumours appearing simultaneously or one shortly after another.

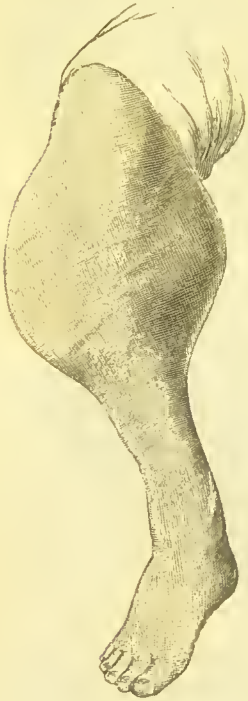

FIG. 205.—Periosteal Sarcoma of Tibia in a woman æt. 60.

Clinical Features.—Sarcomata are usually met with before the age of thirty, and are comparatively common in children. Males are more liable than females in the proportion of two to one.

The symptoms consist in the appearance of a tumour connected with a bone, which steadily increases in size. It may be on one aspect or may surround the bone, and when it occurs at the end of a long bone the swelling frequently assumes the characteristic shape of a leg of mutton (Fig. 205). Its surface may be uniform or bossed, and its consistence varies with its situation, whether central or periosteal, with its structure, and with the changes which it has undergone. The coexistence of solid and fluctuating areas is characteristic. On firm pressure fine crepitation may be felt from crushing of the delicate framework of new bone, or in central tumours there may be parchment-like or egg-shell crackling from yielding of the thin, unresisting shell under the pressure of the fingers. The swelling may pulsate, and a bruit may be heard over it. The patient often complains of pain, which is aggravated by exertion, and which is worst at night. The pain is said to be more severe in central tumours before they erupt on the periosteal surface.

The soft parts over the tumour may for a long time preserve their normal characters; or, they may become œdematous, and the subcutaneous venous network may become evident through the skin. The local elevation of temperature over the tumour, which may amount to two degrees or more, is a point of diagnostic importance.

The adjacent joint usually remains intact, but its movements may be impaired from the mere bulk of the tumour, from effusion, or from portions of the tumour tissue growing towards and into the cavity of the joint.

When the overlying soft parts are invaded, they become matted to each other and adherent to the skin, which is thinned, stretched, and finally sloughs. The tumour tissue then protrudes, fungates, and bleeds. These changes are sometimes hastened by puncture or incision of the swelling made for purposes of diagnosis. Pathological fracture may be an early manifestation of the disease, especially if it involves the shaft of the femur or humerus; it follows slight violence, and is unattended with much ecchymosis or swelling. The fracture very rarely consolidates, although there is often an attempt at union by the formation of cartilaginous callus.

Suppuration may take place in the soft parts over the tumour, especially when an exploratory puncture has been made without antiseptic precautions. Enlargement of the neighbouring lymphatic glands does not necessarily imply that they have become infected with sarcoma, for the enlargement may disappear after removal of the primary growth. Actual infection of the glands may occur, however. As the tumour progresses there is evening pyrexia, the patient emaciates, is worn out with pain, want of sleep, and superadded septic infection, and finally succumbs, with or without evidences of secondary growths. When they occur the secondary growths are most frequently met with in the lung or pleura; but they may develop in any of the organs or in other bones, or may be generalised throughout the body.

The *diagnosis* of sarcoma of bone must be made at an early stage of the disease, in order to obtain a reasonable prospect of cure by operation. At the present day chief reliance is to be placed on information gained by examination with the X-rays and by exploratory incision. In skiagraphy chief attention is to be paid to any alteration in the contour and density of shadow of the affected bone. Exploratory incision is to be supplemented by microscopical examination of the suspected tissue. The lesions likely to be confused with sarcoma are chronic inflammatory conditions of bone, whether staphylococcal, syphilitic, or tuberculous, chronic inflammatory conditions of the adjacent joint, and innocent tumours and hydatid cysts of bone. Secondary cancer of bone may present the same clinical appearances as sarcoma, and may be mistaken for it unless its connection with a primary cancer elsewhere is recognised.

Skiagraphy is not only of assistance in differentiating new growths from other diseases of bone, but may also yield information as to the situation and nature of a tumour, which may have important bearings on treatment.

The *prognosis* of sarcoma of bone varies with the period at which it is recognised, with its malignancy as indicated by its rapidity of growth, and with its situation as bearing on the possibility of complete removal by operation. Growths on the skull, spine, or pelvis rarely lend themselves to surgical interference. In the case of the limbs the prognosis is graver the nearer the disease is to the trunk, because of the greater uncertainty of the disease being completely removed, and also because of the greater mortality which attends high amputations.

Treatment.—Those tumours which lend themselves to operative interference should be removed at the earliest possible moment. Until within recent years the invariable practice has been to perform amputation well above the growth where one of the bones of a limb is involved, and this is still to be recommended as a routine procedure. It must be added, however, that conservative operations of the nature of resections have been performed, and in some instances with success, even in the case of cellular sarcomata (Mikulicz).

Before performing amputation for a supposed sarcoma the tumour should be cut into to make certain of its nature.

In amputating it is not always necessary to go as high as the joint above, provided the tissues are divided well above the tumour; skin-flaps with circular division of muscles is the method of choice. In tumours involving the upper end of the femur it may be necessary to remove one half of the pelvis along with the extremity; and in those of the upper end of the humerus, to remove the shoulder girdle along with the arm. In cases where removal of the tumour can hold out no prospect of permanent recovery, discharge or hæmorrhage may be a sufficient indication for amputation; and in cases where pain is a prominent feature, it may be worth while to remove the tumour, or trephine the shell of the bone.

The operative treatment of sarcoma of the bones of the head and trunk is considered in the sections dealing with these regions.

Pulsating Hæmatoma or Aneurysm of Bone.—A limited number of these tumours are of the nature of cavernous erectile tumours dating from a congenital angioma. The majority would appear to be the result of changes in an already-existing tumour — sarcoma, endothelioma, or myeloma. The tumour tissue largely or entirely disappears, while the vessels and vascular spaces undergo a remarkable development. The disappearance of the tumour tissue may be the result of a large hæmorrhage within the unyielding shell of bone. The tumour may come to be represented by one large blood-containing space communicating with the arteries of the limb; the walls of the space consist of the remains of the original tumour—plus a shell of bone of varying thickness. The most common seats of the condition are the lower end of the femur, the upper end of the tibia, and the pelvic bones.

The *clinical features* are those of a pulsating tumour of slow development. The tumour may attain such dimensions that it no longer suggests to the observer that it originates inside the bone, unless he is able to recognise the parchment or egg-shell crackling on forcibly pressing it with the fingers. As in true aneurysms, pulsation and bruit disappear on compression of the main artery above.

Treatment.—In malignant cases involving the bones of the limbs amputation is indicated; in the pelvis operative treatment is usually out of the question. When there is reason to believe that the tumour is innocent one may consider the possibility of a conservative operation, resembling that known as the old operation for true aneurysm. There are cases on record in which ligature of the main artery of the limb has resulted in permanent cure.

Secondary Tumours of Bone.—These include all varieties of tumours which are capable of occurring by metastasis, and those which spread to the bone by direct contiguity.

Metastatic Tumours.—*Secondary cancer* is a comparatively common disease in bone. Its characters depend on the nature of the primary growth from which it arises. The soft forms grow rapidly, and are characterised by eating away of the bone. In slowly growing forms there may be considerable formation of an imperfectly organised bone, often deficient in lime salts; this condition may be widely diffused throughout the skeleton, and has been described as cancerous osteomalacia. Secondary cancer of bone may not reveal itself clinically at all, or it may cause pains in the affected bones, or may suddenly attract notice by the occurrence of pathological fracture—as, for example, in the shaft of the femur or humerus. In the vertebræ it is attended with a painful form of paraplegia which may involve the lower, or all four extremities. On the other hand, the disease may show itself clinically as a tumour of bone, which may be of considerable size, and may be mistaken for a primary sarcoma, unless the existence of the original cancer is discovered.

The cancers most liable to give rise to metastasis in bone are those of the breast, liver, uterus, prostate and intestine.

Secondary tumours derived from the thyroid gland require special mention, because they are peculiar in that neither the primary growth in the thyroid nor the secondary growths in the bones are necessarily malignant. They may therefore be amenable to surgical treatment.

Secondary sarcomata, whether derived from primary growths in the bones or in the soft parts, are very much rarer than secondary cancers. They are of little clinical importance, as, with isolated exceptions, they are quite out of the range of operative treatment.

Cancer of Bone resulting from Direct Extension from adjacent Soft Parts.—In this group the bone is involved by the spread of the cancer in the same way as any other tissue. There are two clinical types. The first is met with in relation to *epitheliomata of mucous surfaces*—for example, the palate, gums, antrum, frontal sinus, auditory meatus, and middle ear. They will be described under these special regions. The second is met with in relation to *epithelioma occurring in a sinus*, the sequel of suppurative osteomyelitis or compound fracture. The patient has usually had a discharging sinus for a great number of years. The epithelioma originates at the external or skin orifice of the sinus, and spreads down to the bone and into its interior. Inside the bone the progress of the cancer is resisted by the general sclerosis and obliteration of the medullary canal; and although its progress is slow, the infiltration of the bone is often more extensive than would appear externally. It is recognised clinically by the characteristic epitheliomatous growth in the sinus and its vicinity, and by the offensive nature of the discharge. A similar epithelioma may arise in connection with a chronic ulcer of the leg. The cancer may infect the femoral lymphatic glands. The operative treatment is influenced by the extent of disease in the soft parts overlying the bone, and consists accordingly in wide removal of the diseased tissues, or in amputation.

Cysts of Bone.—With the exception of hydatid cysts, which have been already considered, cysts in the interior of bone are usually the result of the liquefaction of such tumours as chondroma, myeloma, or sarcoma.

CHAPTER XXIX.

DISEASES OF JOINTS.

Definition of terms—Ankylosis: *Varieties.* DISEASES: Errors of development—Bacterial diseases: *Pyogenic; Tuberculous; Syphilitic; Acute rheumatism*—Diseases associated with certain constitutional conditions: *Gout; Chronic articular rheumatism; Arthritis deformans; Hæmophilia*—Diseases associated with affections of the nervous system: *Neuro-arthropathies; Charcot's disease*—Hysterical or mimetic affections of joints—Tumours and cysts—Loose bodies in joints.

Definition of Terms.—The term *synovitis* is applied to inflammatory conditions which are confined to the synovial membrane. It is often associated with effusion into the cavity of the joint, which may be serous, sero-fibrinous, or purulent. The term synovitis, however, should always be used along with some qualifying adjective—such as gouty, gonorrhœal, or tuberculous—which indicates its distinctive pathological nature.

Hydrops, *hydrarthrosis*, and *chronic serous synovitis* are terms employed when the effusion of fluid into the joint is the most prominent clinical feature. Hydrops may occur apart from disease,—for example, in the knee-joint, from repeated sprains,—but is chiefly met with in the chronic and intermittent forms of synovitis resulting from gonorrhœa, tuberculosis, syphilis, arthritis deformans, or arthropathies of nerve origin. It may also occur when there are loose bodies in a joint.

Arthritis is the term applied when not only the synovial membrane but the ligaments, articular surfaces, and it may be also the ends of the bones, are involved in the disease.

As in speaking of synovitis, so in using the term arthritis it is necessary to prefix a qualifying adjective which indicates its nature. According to its etiology, arthritis may assume a dry form or may be attended with effusion into the joint; and this effusion may be serous, as in arthritis deformans, or sero-fibrinous or purulent, as in certain forms of pyogenic and tuberculous arthritis. Wasting of the muscles in the vicinity of the joint is a constant accompaniment of arthritis. It especially affects the extensor muscles, is quantitative rather than degenerative, and the muscles do not show the reaction of degeneration. On account of the involvement of the articular surfaces, arthritis is apt to be followed by one or other form of ankylosis.

The term *empyema* is sometimes employed to indicate that the cavity of the joint is full of pus. It is chiefly observed in chronic suppurative disease of pyogenic or tuberculous origin, and is usually attended with the formation of abscesses outside the joint.

Ulceration of cartilage and *caries of the articular surfaces* are common accompaniments of the more serious and progressive forms of joint disease, and especially those of bacterial origin. The destruction of the cartilage is usually preceded by the formation of granulation tissue derived from the synovial membrane or from the bone marrow; the granulation tissue eats into and replaces the cartilage, giving rise to defects or holes, which are spoken of as ulcers. Ulceration of cartilage and articular caries represent successive stages in the same destructive process, the disappearance of the cartilage being frequently followed by exposure and disintegration of the subjacent bone. The occurrence of ulceration of cartilage and of articular caries is always attended with rigidity of the joint from involuntary muscular contraction, with marked wasting of muscles, and starting pains at night. These *starting pains* are the result of sudden involuntary movements of the joint, and are most likely to occur when the patient is dropping off to sleep. The muscles which hold the joint rigid become relaxed, and the sensitive ulcerated surfaces are thus allowed to jar on one another, causing sudden reflex contraction of the muscles, and the resulting movement is attended with severe pain, which causes the patient to wake with a start. Advanced articular caries is usually associated with some abnormal attitude, and sometimes with dislocation. It may be possible under anæsthesia to make the exposed and crumbling bony surfaces grate upon one another. Should recovery take place, repair is usually attended with union of the opposing articular surfaces either by fibrous tissue or by bone.

The term *disorganisation of a joint* indicates that all the constituent parts are damaged or destroyed. This occurs in the more severe and destructive forms of joint disease, and especially in those of pyogenic or tuberculous origin.

Conditions of Impaired Mobility of Joints.—*Rigidity* is the fixation of a joint by the involuntary contraction of muscles. It is sometimes called false ankylosis because it disappears completely under anæsthesia. It is of special value as a sign of disease in deep-seated joints, such as the hip. *Contracture* is the term applied when the fixation is due to permanent pathological changes in the soft parts surrounding the joint. These changes chiefly consist in shortening of muscles, tendons and their sheaths, ligaments, fasciæ, and skin. As the structures on the flexor aspect are specially liable to undergo shortening, contracture is nearly always associated with flexion. Contracture may result from a number of conditions apart from disease of the joint—for example, from disease in one or other of the adjacent bones, from lesions of the motor nervous mechanism, or from hysteria.

Ankylosis is the term applied when impaired mobility of a joint results from changes involving the articular surfaces. It is frequently combined with contracture and with thickening and induration of the capsular and other ligaments. Three anatomical varieties of ankylosis are distinguished—(*a*) The *fibrous*, in which there are fibrous adhesions between the opposing surfaces. These adhesions may be in the form of loose isolated bands, or they may bind the bones closely together in such a way as to obliterate completely the cavity of the joint. The resulting stiffness may vary, therefore, from a mere restriction of the normal range of movement up to a close fibrous union of the bones which altogether prevents movement. Fibrous ankylosis may follow upon injury, especially dislocations and fractures implicating a joint, or may result from any form of arthritis. (*b*) *Cartilaginous ankylosis* implies the fusion of two opposed cartilaginous surfaces. It is best seen between the patella and trochlear surface of the femur in certain forms of tuberculous disease of the knee. The fusion of the cartilaginous surfaces is preceded by the spreading of a vascular connective tissue, derived from the synovial membrane, over the articular surfaces. Clinically, it is associated with ab-

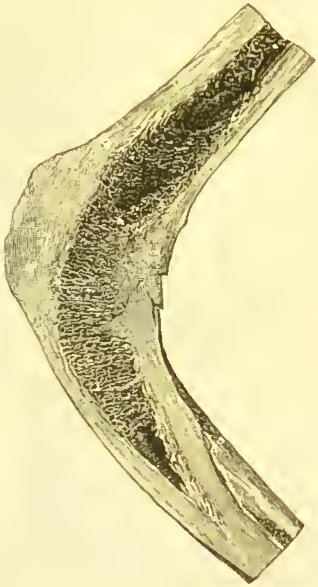

FIG. 206.—Osseous Ankylosis of Femur and Tibia.

solute rigidity. (*c*) *Bony ankylosis* or synostosis is an osseous union between articulating surfaces (Figs. 206 and 207). It may follow upon fibrous or cartilaginous ankylosis, or may result from the fusion of two osseous surfaces which have lost their cartilage and become covered with granulations. In the majority of cases it is to be regarded as a reparative process, presenting certain analogies with the union of fractures. It may be a sequel of any disease of joints, and especially of such as are attended with suppuration.

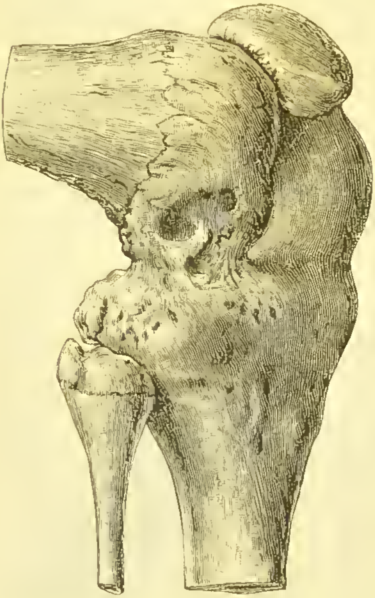

FIG. 207.—Osseous Ankylosis of Knee following upon Tuberculous Disease.

(Anatomical Museum, University of Edinburgh.)

In addition to these forms of osseous ankylosis, which are clearly reparative in nature, others occur, the etiology and pathology of which are as yet unknown. The name arthritis ossificans has been applied by Griffiths to one group of these exceptional cases. The alleged occurrence of ankylosis from mere disuse of a joint has not been corroborated.

The occurrence of ankylosis in a joint before the skeleton has attained maturity has very little influence on the growth in length of the bones affected. Any arrest of growth which may occur is more likely to depend on changes in the epiphysial junctions resulting from the original disease than upon the fusion of the bones.

In order to diagnose between muscular fixation and ankylosis, it may be necessary to anæsthetise the patient. The nature and extent of ankylosis may be learned by manipulating the limb or by skiagraphy. In fibrous ankylosis mobility may be elicited, although only to a slight degree and with pain; while in osseous ankylosis the joint is rigidly fixed, and attempts to move it are painless.

The *treatment* is influenced by the nature of the original disease, the variety of the ankylosis, and the attitude and functions of the joint concerned. In a case of fibrous ankylosis, if the aim be a movable joint, treatment is directed towards elongating or rupturing the fibrous union between the bones.

Elongation of the adhesions may be effected by manipulations, exercises, and the use of special forms of apparatus—such as extension, or the application of weights to the limb. Massage, douching, and electricity are also useful. This line of treatment, however, demands considerable patience and fortitude on the part of the patient, and some encouragement such as is afforded by indications of yielding on the part of the adhesions. It may be necessary to administer an anæsthetic in order to rupture strong fibrous adhesions. These often give way with an audible crack. This procedure must be carried out with caution, in view of such risks as fracture of the bone—which is often rarefied—or separation of an epiphysis. There is also a risk of fat embolism, and of re-starting the disease. In any case the procedure is followed by considerable pain and effusion into the joint, which necessitate rest for some days before exercises and other manipulations are resumed.

In selected cases of fibrous ankylosis, with or without contracture, it may be advisable to attempt to secure a movable joint by open arthrotomy, dividing or removing adhesions and other contracted tissues. This procedure, which has been named *arthrolysis*, has been chiefly practised in the elbow, and has yielded results which are distinctly encouraging.

If the ankylosis is osseous and a movable joint is desired,—for example, at the elbow,—a considerable amount of bone, and it may be also of periosteum and capsular ligament, may require to be resected to allow of the formation of a false joint.

On the other hand, if osseous ankylosis has occurred with the limb in a good position it should be left alone.

When bony ankylosis has occurred with the joint in an undesirable attitude,—for example, flexion at the hip or knee, or extension at the elbow,—it can only be remedied by an osteotomy or a wedge-shaped resection of the bone, with or without such additional division of the contracted soft parts as will permit of the limb being placed in the attitude desired. The fixation of the bones to each other by means of pegs may hasten the occurrence of osseous union, and afford an additional security of the correct attitude being maintained.

Bony ankylosis of the joints of a finger, whether the result of injury or disease, is difficult to remedy by any operative procedure, for while it is quite possible to restore mobility, the new joint is apt to be flail-like and useless. In those who find that the stiff finger is always in the way, and who have little regard for appearances, it is usually best to remove it.

Errors of Development.—These include congenital dislocations and other deformities of intra-uterine origin, such as abnormal laxity of joints, absence, displacement, or defective growth of one or other of the essential constituents of a joint.

The more important of these are described along with deformities.

DISEASES OF JOINTS.

Bacterial Diseases.—In the great majority of bacterial diseases the organisms are carried to the joint in the blood-stream. They may lodge in the first instance either in the synovial membrane or in one of the adjacent bones, whence the disease subsequently spreads to the structures of the joint. Bacterial diseases resulting from infection of a penetrating wound are comparatively rare.

PYOGENIC DISEASES.

The commoner pyogenic diseases are the result of infection of one or other of the joint structures with *staphylococci* or *streptococci*, which may be demonstrated in the exudation into the joint and in the substance of the synovial membrane. The mode of infection is the same as in the pyogenic diseases of bone. The localisation of the infection in a particular joint is determined by injury, exposure to cold, antecedent disease of the joint, or other factors whose nature is not always apparent. A distinction may be made between those diseases in which the organisms involve articular structures from the outset, and those in which the initial lodgment is in one of the adjacent bones. The former are more often met with in adults, and are illustrated by the joint suppurations in pyæmia. The latter are more frequent in children, and are illustrated by the well-known "acute arthritis of infants," in which the joint lesion owes its origin to an osteomyelitis in one of the adjacent bones.

The *clinical features* vary with the gravity of the infection. The disease may assume the form of an *acute serous synovitis*, which may recover, may become chronic, or may relapse after apparent cure. This *relapsing* or *intermittent synovitis* or hydrops has been shown to depend in certain cases on chronic staphylococcal disease of one of the adjacent bones, the treatment of which is essential for permanent recovery. It closely resembles that of gonorrhœal or tuberculous origin.

In certain cases of pyogenic infection the disease remains latent for a time, and the clinical manifestations are so slight that they entirely escape notice until some striking development, such as dislocation in the case of the hip-joint, draws attention to them. The detection of ankylosis may be the first evidence that the joint has been diseased. This latency is chiefly observed when the joint has become infected in the course of some acute illness, such as scarlet or typhoid fever, or pyæmia.

In the graver infections the suppurative element is more prominent, the effusion into the joint soon becoming purulent, and there is general illness, often ushered in with a rigor. The local signs and symptoms are those of an *acute arthritis*, in which all the joint structures participate, and which, if left to itself, may result in disorganisation.

The synovial membrane is converted into granulation tissue. The ligaments and inter-articular cartilages share a similar fate. The articular cartilages, which are at first dulled and macerated, undergo fibrillation and necrosis and separate in visible fragments. The marrow of the subjacent bone thus exposed becomes the seat of inflammation and throws out granulations which appear on the articular surface and lead to a disintegration of the bone, commonly described as articular caries.

The joint is held rigid by the involuntary contraction of muscles, and the least attempt at movement causes severe pain. The slightest jar—even the shaking of the bed—may cause agony. Sleep is impossible, or is disturbed by starting pains. Distension of the joint and fluctuation may be evident, or they may be obscured by œdema of the overlying soft parts. Sometimes the entire limb is swollen and œdematous. In untreated cases the joint usually becomes flexed.

The pus formed in the joint may perforate the capsule and spread in the surrounding tissues. Sooner or later the abscess ruptures on the surface and discharges through one or more sinuses. The final disorganisation of the joint, with destruction of its ligaments, may be indicated by abnormal mobility, by grating of the articular surfaces, or by dislocation. In the acute arthritis of infants the epiphysis concerned may be separated and displaced. The progress of the local disease is associated with aggravation of the general symptoms, and the patient is poisoned with toxins and exhausted by suffering.

In the course of *pyæmia*, joints may become distended with pus without any pronounced changes in the joint structures, without local signs except those indicating the presence of fluid, and without much complaint on the part of the patient.

When the joint is infected through an external wound, either accidental or operative, the morbid anatomy and clinical features are similar to those described when the infection has been carried to the joint by the blood-stream; but the lesion is usually more severe and destructive, and if not fatal is more likely to persist and result in osseous ankylosis.

The terminations vary with the gravity of the infection and with the stage at which it comes under surgical treatment. In the milder forms recovery is the rule, with more or less complete restoration of function. In the more severe forms, and especially when several joints are involved, death may result from septic absorption. If the patient recovers, the joint or the entire limb may be permanently damaged. There may be fibrous or bony ankylosis, in a good or in a bad position, or there may be deformity from displacement or dislocation. From changes in the peri-articular structures there may be contracture of the limb in an undesirable position, and in the case of young subjects there may be interference with the growth of the limb. The persistence of sinuses is usually due to disease in one or other of the adjacent bones.

The *diagnosis*, while easy and straightforward in the graver suppurative forms, may be difficult in the milder varieties, for these may resemble very closely the serous effusions met with in gonorrhœa or tuberculosis.

The treatment is governed by the same principles as guide us in the treatment of other pyogenic infections. The limb is immobilised and elevated in such an attitude that should stiffness occur there will be the least possible interference with function. Extension by weight and pulley may relieve symptoms and counteract any tendency to flexion.

While the application of ice to the joint or the use of leeches is sometimes recommended, we prefer an antiseptic compress of 1 in 40 carbolic lotion, or, in the case of children, of boracic lotion. A more important question is that of evacuating the fluid in the joint. If this is in sufficient quantity to cause tension, or if it tends to persist, or if from the temperature and other indications there is reason to suspect that it is purulent, it should be evacuated without delay. A trocar and cannula may suffice in the serous variety; but the suppurative forms demand incision and drainage. In addition, the joint may be gently washed out with salt solution or peroxide of hydrogen. It is a common experience that many forms of acute suppuration in joints—for example, the acute arthritis of infants, and the suppurations in pyæmia—yield at once to incision and drainage if carried out sufficiently early and before any destructive changes have taken place.

On the other hand the results of simple drainage may be unsatisfactory. Indications of progressive mischief may call for further interference. Continuous irrigation with several openings for drainage may be tried, or the joint may be laid freely open so that every pocket and recess is exposed. In certain joints this is only attainable by the resection of one or other of the bones.

The existence of suppuration in the peri-articular soft parts or in one of the adjacent bones must be looked for and promptly dealt with.

Amputation is only to be had recourse to if life is threatened by general infection.

When convalescence is established, attention is directed to the restoration of the functions of the limb, to the prevention of stiffness and deformity by movements and massage, and the use of hot air and other baths.

At a later stage, and especially in neglected cases, operative and other measures may be required for deformity or stiffness.

Other Forms of Pyogenic Infection.—In *typhoid fever* joint lesions may result from infection with the typhoid bacillus or with ordinary pyogenic organisms. They have been observed, especially in the hip-joint, to run their course with or without suppuration. They are sometimes remarkably latent, but may result in dislocation on slight movement, or on lifting the patient. Ankylosis may occur. They are very amenable to treatment.

Joint lesions are comparatively common in *scarlet fever*. They were formerly described as scarlatinal rheumatism. The most frequent clinical type is that of a serous synovitis, occurring within a week or ten days from the onset of the fever. It is most common in females over fifteen years. Its favourite seat is in the hand and wrist, the sheaths of the extensor tendons as well as the synovial membrane of the joints being involved. It does not tend to migrate to other joints, and rarely lasts longer than a few days. It is probably due to the specific virus of scarlatina.

An arthritis is sometimes met with which may be acute and suppurative, may affect several joints, and may exhibit a grave septicæmic or pyæmic character. It is chiefly met with in children at a later stage of the fever, and in cases in which the throat lesion is severe.

There is also described a "true rheumatic arthritis" occurring when convalescence from scarlet fever is well advanced; this form is favourably influenced by anti-rheumatic remedies, and is sometimes complicated with endocarditis and with chorea.

Pneumococcal arthritis is chiefly met with in one of the large joints in adult males, as a primary affection or as a complication of pneumonia. The changes in the joint affected and the clinical features are those common to all acute pyogenic infections, and the differential diagnosis can only be established by aspiration and bacteriological examination of the fluid in the joint. The prognosis is grave because of the frequency of general pneumococcal infection and involvement of the serous membranes within the skull or thorax. The treatment of the joint lesion is by early incision and drainage.

In *measles*, *diphtheria*, *smallpox*, *influenza*, and *dysentery*, joint lesions may occur, but are less frequent than in typhoid or scarlet fever.

The joint lesions which accompany *acute rheumatism* may be provisionally included with the other members of this group. For a description of them the reader is referred to works on medicine.

Gonorrhœal Affections of Joints.—These include all forms of joint lesion associated with gonorrhœal urethritis or with gonorrhœal ophthalmia. They may develop at any stage of the gonorrhœa, but are usually met with when the infection has reached the posterior portion of the urethra. They have been observed, however, after the discharge has ceased. There is no connection between the severity of the gonorrhœa and the incidence of joint disease. The gouty and rheumatic are supposed to be more liable. The sexes are affected with about equal frequency.

As a complication of ophthalmia the joint lesions are chiefly met with in infants, and occur more commonly towards the end of the second or during the third week.

The joint lesions may be the only evidence of metastatic infection, or they may be part of a gonorrhœal pyæmia, involving the endocardium, the pleura and the tendon sheaths. The gonococcus is nearly always present in pure culture, and is found with most certainty in the synovial membrane, in which it is first deposited from the blood. It may be impossible to find it in the exudation in the cavity of the joint. In the purulent forms the gonococcus alone may be present, or it may be associated with staphylococci or streptococci. The joint affection is more often monarticular than polyarticular.

The order of frequency with which the joints are affected is the knee, elbow, ankle, hip, foot, wrist, shoulder, fingers.

Several clinical types may be differentiated. The mildest is a *dry polyarthritis*—resembling chronic rheumatism—which is sometimes trifling and evanescent, and, it may be, recurring with successive attacks of gonorrhœa. In other cases it is persistent and progressive, and results in partial or complete stiffening of the joints affected and permanent crippling of the patient.

The commonest type takes the form of a *chronic synovitis or hydrops*, in which the joint—nearly always the knee on one or both sides—gradually fills with fluid of a serous or sero-fibrinous character. It may readily subside under rest and then relapse, or it may be very persistent and disabling. When recovery takes place it is usually complete.

A more *acute general arthritis* may begin as such, or may follow on one of the milder forms of the disease. It is most often met with in the elbow. There is a sudden onset of severe pain, swelling, inability to use the limb, and considerable fever. The swelling may extend well beyond the limits of the joint, and may be associated with œdema of the soft parts. The skin is red and hot, and the adjacent tendon sheaths and bursæ, especially at the ankle, wrist and knee, may be simultaneously involved. The tendency towards stiffness and ankylosis is considerable. The ankylosis, at first fibrous from close adhesions between the surfaces, may become bony, and may be associated with flexion or other deformity.

A *suppurative arthritis* like that caused by ordinary pus microbes is met with. It may be the result of gonococcal infection alone or of a mixed infection. It is usually single, but may be multiple, and abscesses may form outside the joint. Fortunately it is rare, as it may endanger the joint, the limb, or even life itself. Recovery is usually attended with ankylosis.

The diagnosis of gonorrhœal affections of joints is often missed, because the existence of gonorrhœa is not suspected by the practitioner. The denial of the disease by the patient is not to be accepted, especially in the case of women, as they may be ignorant of its presence. The chief points in the differential diagnosis from acute rheumatism are, that the gonorrhœal affection is usually monarticular and has little tendency to wander from joint to joint, and that its progress is not appreciably influenced by salicylates, although these drugs may relieve the pain.

The prognosis should always be guarded, because the disease may prove very persistent or may relapse, and the patient may be laid up for weeks or months, and may finally be crippled in one or in several joints.

The treatment—besides that of the urethral disease or of the ophthalmia—consists in rest until all pain and sensitiveness have disappeared. Salicylates or iodides may relieve suffering, but are not curative.

The joint is immobilised by means of a splint, or by cotton wool and an elastic bandage. Extension is employed in the case of the hip.

During the acute stages, great relief may be obtained from very hot baths, to which turpentine and black soap may be added. König recommends the use of tincture of iodine to the extent of blistering. In the persistent dry form the hot-air bath, or Bier's method by venous congestion, may be employed. In hydrops, when the fluid persists, the joint should be tapped, the fluid withdrawn, and a 1 per cent. solution of protargol injected. The purulent form is to be treated by incision and drainage.

After all symptoms have settled down, but not till then, for fear of exciting relapse or metastasis, the joint may be massaged and exercised. Stiffness from adhesions is most intractable, and may, in spite of every attention, terminate in ankylosis, which must be dealt with on general principles. Ankylosis of the elbow is best treated by excision of the joint.

TUBERCULOUS DISEASES.

Tuberculous diseases of joints result from bacillary infection of the synovial membrane, or of the marrow of one of the adjacent bones under conditions similar to those which have been described as occurring in tuberculous diseases of bone.

From the anatomical point of view they may be divided into those in which the disease originates in the synovial membrane, and those in which it originates in one of the adjacent bones. The relative frequency of these two types varies with the age of the patient and with the joint affected. In children the number of cases originating in the bones is approximately three times as great as those originating in the synovial membrane, while in adults the disease most frequently originates in the synovial membrane. As regards the joint affected, the maximum frequency of osseous lesions is found in the hip—in the proportion of five osseous to one synovial (Krause); in the knee, the proportion is about equal (König). In the other large joints the proportion is about equal. The predominance of bone lesions in childhood and youth is to be ascribed chiefly to the conditions associated with the growth of the skeleton, especially at the ends of the long bones.

Morbid Anatomy.—When tuberculous disease is present, either in the form of an area of caseation or of a sequestrum in the spongy bone, it may give rise to reactive changes in the adjacent joint, which are not necessarily tuberculous. These are characterised by effusion into the joint, and by the prolongation of the synovial membrane over the articular surfaces. The formation of adhesions may obliterate the cavity of the joint, or divide it into different compartments. These phenomena are best observed in the knee, and are analogous to the changes met with in the pleura in disease of the lung, and in the peritoneum in disease of the abdominal viscera. These non-tuberculous lesions in joints are comparatively common and are often misunderstood. They are, however, of importance because they interfere with the functions of the joint, and in the event of rupture of the osseous focus into the joint at a later period may limit the infection to a circumscribed area and prevent the development of the graver forms of tuberculous joint disease.

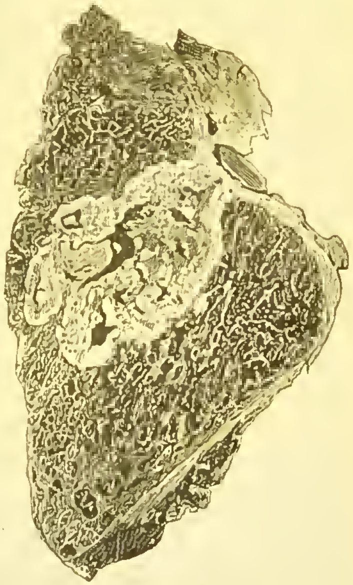

Fig. 208.—Section of Upper End of Fibula, showing caseating focus in marrow, erupting on articular surface and infecting joint.

The actual infection of the joint with tubercle from the adjacent bone may take place at the periphery, the osseous focus reaching the surface of the bone at the site of the reflection of the synovial membrane, the infection beginning at this point, and then spreading to the rest of the membrane. Or it may take place in the central area by tuberculous pus escaping into the joint through a hole in the articular cartilage, or by the projection of tuberculous tissue into the joint following upon gradual erosion of the cartilage (Fig. 208).

In the majority of cases the first evidence of disease in the joint is a *diffuse thickening of the synovial membrane*, chiefly due to the formation of granulation tissue, or young connective tissue, in its substance. This new tissue may be described as being arranged in two layers—the outer layer composed of more fully-formed connective or fibrous tissue, while the inner consists of embryonic tissue, usually permeated with miliary and other tubercles. On opening the joint these tubercles may be seen on the free surface of the synovial membrane, or the surface may be covered with a thin layer of fibrinous or caseous tissue, and a similar material may occupy the cavity of the joint. Where there is greater resistance on the part of the tissues, there is active formation of young connective tissue circumscribing or encapsulating the tubercles, so that they remain embedded in the substance of the synovial membrane, and are only seen on cutting into it.

The new tissue formed in relation to the synovial membrane tends to be projected into the cavity of the joint, filling up its pouches and recesses, and spreading over the surface of the articular cartilages like ivy growing over a wall (Fig. 230). Wherever the synovial tissue covers the cartilage it becomes adherent to and fused with it, as covered cartilage always undergoes a retrograde metaplasia into ordinary connective tissue. The morbid process may be arrested at this stage, and may cure with fibrous adhesions between the opposing articular surfaces, or it may progress, in which case further changes occur which result in destruction of the articular cartilages and exposure of the subjacent bone.

The synovial tissue covering the cartilage may at first present no evidence of the presence of tubercle, but in time it acquires the characters of a tuberculous infiltration and exhibits aggressive qualities. It then causes pitting and perforation of the cartilage, makes its way through it, and often spreads widely between it and the subjacent bone, so as to separate the cartilage, sometimes in portions of considerable size. These are the changes commonly spoken of as ulceration of cartilage. The cartilage is destroyed more rapidly and extensively when it overlies a focus in the bone, and the latter being then exposed in the joint, contributes to the progress of the disease.

Changes in the bone may precede or follow upon destruction of the articular cartilage. These consist in tuberculous infiltration of the marrow in the surface cancelli, and breaking up of the spongy framework of the bone into minute irregular fragments. This disintegration of the bone is known as caries.

When the destructive changes in the articular surfaces are very pronounced, and when at the same time there is an absence of caseation and suppuration, the condition is called caries sicca.

The mutual pressure of articular surfaces against one another favours the progress of ulceration of cartilage and of articular caries. These processes are usually more advanced in the areas most exposed to pressure—for example, in the case of the hip-joint, on the superior aspect of the head of the femur, and on the posterior and upper segment of the acetabulum.

The occurrence of *pathological dislocation* is due to softening and stretching of the ligaments, which normally retain the bones in position, and to some factor causing displacement, which may be the accumulation of fluid or of granulations in the joint, the involuntary contraction of muscles, or some movement or twist of the limb. The occurrence of dislocation is also favoured by destructive changes in the bones.

In rare instances the synovial membrane may present nodular masses or lumps, resembling the tuberculous tumours met with in the brain. They project into the cavity of the joint, are often pedunculated, and may give rise to the same symptoms as a loose body. The fringes of the synovial membrane may also undergo a remarkable development, like that observed in arthritis deformans. Both these types are most frequently met with in the knee-joint.

The Contents of Tuberculous Joints.—In a large proportion of cases of synovial tuberculosis the joint cavity is entirely filled up by the diffuse thickening of the synovial membrane, and there is no fluid in the joint. In a small number there is an abundant serous exudation, and the condition is known clinically as tuberculous *hydrops.* There may be a considerable formation of fibrin within the joint, covering the free surface of the membrane and floating in the fluid as shapeless flakes or masses. Under the influence of joint movements this fibrin may assume the shape of melon seed bodies (Fig. 217). More rarely the joint contains tuberculous pus, and the surface of the synovial membrane resembles the wall of a cold abscess.

Peri-articular tubercle and abscess may result from the spread of disease from the bone or joint into the surrounding tissues, either directly or by way of the lymphatics. A peri-articular abscess may spread in several directions, sometimes invading tendon sheaths or bursæ, and finally reaching the skin surface by tortuous sinuses.

Reactive changes in the vicinity of tuberculous joints are of common occurrence, and play a considerable part in the production of what is known clinically as *white swelling.* New connective tissue forms in the peri-articular fat and between muscles and tendons. It may be tough and fibrous, or soft, vascular, and œdematous, and the peri-articular fat becomes swollen and gelatinous, constituting a layer of considerable thickness from which tubercle may be entirely absent. This is what was formerly known as *gelatinous degeneration.* It is supposed that the fat disappears and is replaced by a mucoid effusion between the fibrous bundles of connective tissue, and that these changes result from interference with the circulation and nutrition of the tissues concerned. In the case of the wrist the newly-formed connective tissue may fix the tendons in their sheaths, seriously interfering with the movements of the fingers. In relation to the bones there may also be reactive changes, resulting in the formation of spicules or scales of new bone on the periosteal surfaces and at the attachment of the capsular and other ligaments.

Terminations and Sequelæ.—The disease may spontaneously cure at any stage, the tuberculous tissue being replaced by healthy connective and scar tissue. Recovery is apt to be attended with impairment of movement due to the occurrence of limited adhesions, or ankylosis, or contraction of the peri-articular structures. Caseous foci in the interior of the bones may become encapsulated, and permanent cure thus be effected, or they may be the cause of a relapse of the disease at a later date. Interference with growth is comparatively common, and may involve only the epiphysial junctions in the immediate vicinity of the joint affected, or all the bones of the limb. This is sometimes well seen in adults who have suffered from disease of the hip in childhood—the entire limb, including the foot, being shorter and smaller than the corresponding parts of the opposite side.

Atrophic conditions are also met with, the bones undergoing fatty atrophy, so that in extreme cases they may be cut with a knife or may easily fracture. This is to be borne in mind in forcibly manipulating stiff joints. These atrophic conditions are recovered from if the limb is able to resume its functions.

Relative Frequency of Tuberculous Disease in different Joints.—Hospital statistics lead us to place the various joints in the following order of frequency:—Spine, knee, hip, ankle and tarsus, elbow, wrist, shoulder. It is probable that the frequency in the joints of the upper extremity is understated, because the subjects thereof are often treated as out-patients.

Relative Frequency of different Joints at different Ages.—Tuberculosis of the hip and spine are essentially diseases of childhood and youth, and rarely commence after the skeleton has attained maturity. Disease of the knee is very common in children, but may be met with at any period of life. The elbow and ankle exhibit little age preference, but are chiefly affected

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during childhood and youth. The wrist and shoulder are rarely affected in children.

Clinical Features.—These vary with the different anatomical forms of the disease, with the joint affected, and with the individual tendencies of the patient. The symptoms do not always correspond with the nature and severity of the local lesions, and it is not uncommon to find, when the joint is exposed by operation, that the disease is much more extensive than might have been inferred from the clinical features.

The onset is usually insidious, its exact date being difficult to determine, so that it is often misstated by the patient. Sometimes the disease is ushered in with fever and with pains in several joints. This was described by John Duncan under the title, "Tuberculous arthritic fever." It is liable to be mistaken for rheumatic fever, from which, however, it may usually be distinguished by the absence of any real migration from joint to joint, by the absence of sweating, of visceral complications, and of benefit from salicylates.

The initial local symptoms may be those associated with the presence of a focus in the neighbouring bone, perhaps causing neuralgic pains in the joint, or weakness, tiredness, stiffness, and inability to use the limb, the symptoms improving with rest and being aggravated by exertion.

It is rarely possible by external examination to recognise deep-seated osseous foci in the vicinity of joints; but if they are near the surface in a superficial bone—such as the head of the tibia—there may be local thickening of the periosteum, œdema, pain, and tenderness on pressure and on percussion. Large foci may be revealed by the X-rays. The patient may not be seen until an abscess or a sinus has formed.

In exceptional cases, tuberculous joint disease follows an acute course resembling that of the pyogenic arthritis of infants. This has been observed, especially in the knee, in very young children, the lesion being in the synovial membrane, and being attended with an accumulation of pus in the joint. If promptly treated by incision and drainage recovery is rapid, and free movement of the joint may be preserved.

The onset and early stages of tuberculous disease, however, are more often insidious, and are attended with so few symptoms that the disease may have obtained a considerable hold before it attracts definite notice. It is not uncommon for patients or their friends to attribute the disease to injury, as it often becomes more active after excessive use of the limb or some slight trauma. The symptoms may subside under rest, only to relapse again with use of the limb, and this may occur repeatedly. The milder forms of synovial tuberculosis may be entirely recovered from, but the more severe bone lesions tend to cause aggravated forms of joint disease which have little tendency to natural cure. The presence of bone lesions may be inferred from the mere persistence of the disease in spite of proper treatment.

In addition to the ordinary symptoms of joint disease—such as pain, swelling, and heat—attention must be specially directed to the wasting of muscles, the impairment or loss of the normal movements of the joint, and the development of abnormal attitudes of the limb.

Wasting of the muscles is a constant accompaniment of tuberculous joint disease. It is attributed partly to want of use, but chiefly to reflex interference with the trophic innervation of the muscles. It is especially well seen in the extensor and adductor muscles of the thigh in disease of the knee, and in the deltoid in disease of the shoulder. The affected muscles become soft and flaccid, they exhibit tremors on attempted movement, and their excitability to the faradic current is diminished. The muscular tissue may be largely replaced by fat.

Impairment or loss of the normal movements varies in degree according to the nature and seat of the disease. In the early stages of synovial tuberculosis the movements may be merely restricted in range. When any of the joints of the lower extremity is affected there is usually a limp in walking. When the articular surfaces are involved all movements, whether active or passive, are usually abolished, and the condition presented is one of fixation or rigidity. This results from involuntary contraction of the muscles; it disappears under an anæsthetic, but returns on waking. The recognition of rigidity is of great diagnostic value, especially in deeply-seated joints such as the shoulder and hip, and in the spine.

Abnormal attitudes of the limb may precede other symptoms of joint disease, but are more frequently of later development. In very indolent and mild cases they may be absent altogether. They occur earlier, and are more pronounced in cases in which pain and other irritative symptoms of articular disease are well marked. They are best illustrated by the attitudes assumed in disease of the hip and knee. They are due to reflex or involuntary contraction of the muscles acting on the joint, with the object of placing it in the attitude of greatest ease. These attitudes disappear under chloroform unless secondary changes have occurred, causing contracture or ankylosis. With the lapse of time these attitudes not only become exaggerated, but may become permanent from ankylosis, or from contracture of the soft parts around the joint.

Startings at night, which are frequently met with in the stage of muscular fixation, are to be regarded as indications that the disease of the articular surfaces is progressive. They are more often met with in cases which go on to suppuration.

The formation of abscess is one of the commonest accompaniments of tuberculous joint disease. It may appear early and play a prominent part in the clinical picture, or it may not develop till long after the original disease has subsided. Its formation is often attributed to a slight injury. It may develop so insidiously that it may not attract attention until it has attained considerable size, especially when associated with disease of the spine, pelvis, or hip. The abscess presents itself at definite situations in relation to the different joints, its position being determined by the anatomical relationships of the capsule and synovial membrane to the surrounding tissues. The bursæ and tendon sheaths in the vicinity when infected may influence the direction of spread of the abscess and the situation of resulting sinuses. The formation of abscess in the course of tuberculous joint disease may sometimes be an advantage, as it may render a tuberculous focus more amenable to treatment, especially by the injection of iodoform. When left to burst of itself, however, or when opened and allowed to become infected with pyogenic bacteria, there is not only the risk of aggravation of the disease and persistent suppuration, but there is a greater liability to general tuberculosis.

When sinuses form, they are often so tortuous that it may be difficult or impossible to pass a probe down to the focus from which the abscess took its origin.

Infection of the lymphatic glands of the limb is exceptional as a result of joint disease, but it may follow upon tuberculous infection of the skin around the orifice of a sinus.

The occurrence of *pyrexia* in tuberculous joint disease usually indicates suppuration, or the dissemination of the tubercle—for example, to the lungs or membranes of the brain. A slight rise of temperature in the evening may be induced in quiescent joint lesions by injury or by movement of the joint under chloroform, or by such extra exertion as a railway journey. The development and spread of an abscess may also be attended with an evening rise of temperature; but when the abscess is quiescent the temperature usually remains normal. A carefully-taken temperature chart, therefore, may afford useful information as to the formation or spread of an abscess. When sinuses have formed and become septic, there may be a diurnal variation in the temperature of the type known as hectic fever (Fig. 2).

TYPES OF TUBERCULOUS JOINT DISEASE.

Tuberculous hydrops is nearly always the result of a purely synovial lesion, and its outstanding feature is the accumulation of fluid within the joint. It is analogous to the ascitic form of peritoneal tuberculosis and to the effusion in tuberculous disease of the pleura. It is the chief representative of the "chronic simple synovitis" of the older authors. Inasmuch as it frequently terminates in recovery with a useful joint, it may be regarded as the least serious form of tuberculous joint disease. As it is most often met with in the knee, it will be described with the affections of that joint.

Cold Abscess or Empyema of Joints.—The special feature of this type consists in the accumulation of tuberculous pus within the joint. It is analogous to the purulent type of peritoneal tuberculosis and tuberculous empyema of the pleura. It is most often met with in the knee, and is usually the result of tuberculosis starting in the synovial membrane. It is met with in those who are much reduced in health, and who are the subjects of tuberculous lesions elsewhere. Its clinical features resemble those of hydrops so closely that the differential diagnosis is rarely made until the fluid is withdrawn by means of a trocar and cannula. The prognosis is less favourable than in hydrops, because of the feeble resisting powers of the patient.

Diffuse Thickening of the Synovial Membrane.—White Swelling of Joints.—*Tumor albus* was the name originally applied by Wiseman in 1676 to that form of tuberculous disease which is characterised by the gradual development of an elastic swelling in the region of a joint. It has already been pointed out that this swelling is to a considerable extent the result of inflammatory and mucoid changes in the fat and connective tissue surrounding the capsule of the joint, as well as of tuberculous thickening of the synovial membrane. It may originate from tuberculosis starting in the synovial membrane as well as from disease in the bone. The changes within the joint and the course of the disease vary within very wide limits. The appearances of white swelling bulk so largely in the clinical features of a large number of cases of tuberculous joint disease that it is probably the best known clinical type. It is best illustrated in joints which are superficial—such as the knee, ankle, elbow, and wrist. The swelling, which is the first and most prominent clinical feature, develops gradually and painlessly, obliterating the bony prominences by filling up the natural hollows (Fig. 220). It appears greater to the eye than is borne out by measurement, being thrown into relief by the wasting of the muscles above and below the joint. In the early stage the swelling is elastic, doughy, and non-sensitive, and corresponds very accurately to the superficial area of the synovial membrane involved. At this stage there is comparatively little complaint on the part of the patient, for the articular surfaces and ligaments are still intact. There may be a feeling of weight in the limb, and in the case of the knee and ankle the patient may tire on walking and drag the leg with more or less of a limp. The movements of the joint are painless, although usually somewhat limited in range. The disability is increased by use and exertion, but for a time at any rate improves under rest.

As the disease progresses the signs and symptoms slowly become more marked. The skin over the joint becomes tense and hot, the swelling, which was at first firm and elastic, may show areas of softening, and later of fluctuation; and a cold abscess may form and produce one or more sinuses by bursting through the skin (Fig. 234). The wasting of muscles increases, the joint becomes more rigid as the articular cartilages become affected, and the attitude of flexion is very commonly assumed, more especially in the case of the knee. Starting pains at night indicate destructive changes in the articular surfaces. The final condition tends to be one of disorganisation of the joint, with septic sinuses and deformity.

Tuberculous Arthritis.—It is convenient to group under this heading those cases of tuberculous joint disease in which the early and outstanding clinical features are the result of implication of the articular surfaces. Although, as already indicated, these symptoms commonly develop in the later stages of white swelling, it is a matter of everyday experience that symptoms of implication of the articular surfaces may be the first evidence of tuberculous joint infection, and may exist without white swelling or any other clinical sign of disease in the synovial membrane. These remarks specially apply to such deeply-seated joints as the hip, shoulder, and spine. The recognition of this form of tuberculous joint disease depends rather upon inferences founded upon certain symptoms and signs than upon direct examination of the joint itself. The patient complains of pain in the joint affected, or refers it to some other part which shares the same nervous supply; for example, in hip disease the pain is often referred to the knee through the obturator nerve. The pain is aggravated by movement, and in the case of the joints of the lower extremity the patient limps in walking. The movements of the joint are restricted or abolished. Wasting of muscles is more marked than in the early stage of white swelling. Very commonly the limb assumes an abnormal attitude as a result of the contraction of particular groups of muscles.

In the more advanced stages, other signs may make their appearance, such as starting pains, the formation of abscess and of sinuses, displacement, or even dislocation of the bones. Under an anæsthetic the joint may be found to be completely disorganised, with destruction of ligaments, abnormal mobility, and grating of the articular surfaces.

Caries sicca is the name given by Volkmann to a very chronic form of tuberculous arthritis, which is chiefly met with in the shoulder and hip between the ages of fifteen and thirty-five. There is an entire absence of swelling, a characteristic wasting of all the structures in the vicinity of the joint, and the bony prominences—such as the acromion and coracoid in the case of the shoulder, and the trochanter at the hip—stand out prominently. Passive movements are restricted and are attended with severe pain. The general health usually remains unimpaired in spite of the long duration of the disease. Suppuration is exceptional, and when it occurs is usually associated with the presence of a sequestrum.

Influence of tuberculous Joint Disease on the General Health.—Experience shows that tuberculous joint disease may be compatible with the appearance of good health. As a rule, however, the general health suffers, the appetite is impaired, the patient is easily tired and complains of failure of strength, and there may be considerable loss of flesh.

Tuberculous disease of the lung is very frequent in the case of adults, and may be present when the joint disease begins, or may appear later. In the case of children acute miliary tuberculosis may occur, and is usually rapidly fatal; it sometimes follows on comparatively trivial operations, and the clinical features are frequently those of tuberculous meningitis. A considerable number die from exhaustion with the phenomena of hectic fever.

Diagnosis.—The diagnosis is usually easy in typical cases. We should not be misled by the patient being up in years or by his appearance of good health. A history of tuberculosis in the family, or of other tuberculous lesions in the patient, an insidious onset, and the fact that there is a considerable interval between the receipt of an alleged injury and the appearance of symptoms, all suggest the tuberculous origin of a given case of joint disease. The X-rays are chiefly of value in the recognition of osseous lesions. The use of Koch's tuberculin for diagnostic purposes is not to be recommended.

The prognosis varies with the seat, the extent, and the severity of the local disease, and with the resisting powers of the patient, as influenced by his general health, age, and social circumstances. Recovery is seldom impossible, but the existence of tuberculous lesions elsewhere or of septic sinuses are unfavourable factors. While tuberculous lesions in children tend to become circumscribed, the tendency in adults is in the opposite direction. The locality of the disease is an important factor, the prognosis being much more unfavourable in the hip and spine than in other joints.

The length of time required for complete recovery necessarily varies, but may be stated generally as being from one to three years. The patient or his friends must be informed of this, and of the risk of relapse at some future period.

Treatment.—Apart from that applicable to all forms of tuberculosis, we are here concerned with the local measures directed towards the disease in the joint. These may be described under two heads—the conservative and the operative.

Conservative treatment is almost always to be employed in the first instance, since a larger proportion of cures is obtained with a less mortality and with better functional results than by operation. Only when conservative measures fail is recourse to be had to operative methods. Conservative treatment is most applicable and most successful in cases where the skin is still intact; it includes the placing of the joint at complete rest, the correction of abnormal attitudes, the production of venous congestion, and the injection of iodoform or other antiseptic agent.

Treatment by rest implies the immobilisation of the diseased limb until pain and tenderness have disappeared. It is carried out by means of bandages, plaster of Paris splints, or other apparatus, according to the joint affected. The attitude in which the limb is immobilised should be that in which, in the event of subsequent stiffness, it will be most serviceable to the patient. *Extension* with weight and pulley is of great value, especially in disease of the hip or knee; it eliminates muscular spasm, relieves pain and startings at night, and prevents or corrects abnormal attitudes of the limb. When the patient first comes under observation, if the limb is in a deformed attitude which does not readily yield to extension, it should at the outset be corrected under an anæsthetic. The permanently deformed attitudes due to contraction of the soft parts or to ankylosis will be considered later.

The Injection of Iodoform.—In hydrops and empyema of joints this is carried out on the same lines as have been described for tuberculous abscess. The fluid contents of the joint are withdrawn, after which the iodoform emulsion is injected. The injection may require to be repeated in a month or six weeks.

When there is no fluid in the joint,—as, for example, in white swelling,—the conditions for distributing the iodoform are less favourable. In the knee the joint may be divided up into compartments by septa of connective tissue derived from the synovial membrane, and the iodoform must be introduced into all of them. The trocar must be thrust in all directions, successive parts of the joint being attacked at intervals of from ten to fourteen days. Injections into the substance of the synovial membrane are less certain, are more painful, and require greater pressure on the piston of the syringe. Mikulicz and others attempt to inject the iodoform into the adjacent bones when these are soft enough to allow of the entrance of the trocar. Wherever the iodoform is introduced it remains for long periods, and may be seen as a dark shadow in skiagrams.

After the injection of iodoform there is usually considerable reaction attended with fever (101° F.), headache, and malaise, and considerable pain and swelling of the joint. In some cases there is sickness, and there may be blood pigment in the urine. The severity of these phenomena diminishes with each subsequent injection.

The artificial production of venous congestion introduced by Bier is, if carefully supervised, an important adjuvant to the iodoform treatment. Two or three turns of elastic webbing are applied outside a layer of lint a short distance above the affected joint, sufficiently tightly to constrict the veins and produce a bluish-red tinge of the skin. Below the joint the limb should be bandaged to prevent œdema. The site of application of the elastic bandage is frequently changed, to avoid injuring the skin and to diminish the tendency to wasting of the muscles. The congestion is maintained for from fourteen to eighteen hours each day. In the interval the œdema around the joint may be dispelled by a bandage. The congestion appears to act beneficially by stimulating the formation of connective tissue. It has been objected to by some surgeons, because under its influence a latent tuberculous focus may be transformed into a cold abscess. In our opinion, however, this is no drawback, as the cold abscess is more amenable to iodoform treatment than the latent focus. The congestion should be persevered with, until a month or two after the joint disease appears to have been cured. The congestion should be suspended for two or three days after the injection of iodoform. The external application of iodine, or of mercurial ointment in the form of Scott's dressing, are alternative methods of treatment to that by iodoform. The use of blisters and of the actual cautery has largely gone out of fashion, but they may be employed with benefit for the relief of pain when this is a prominent feature. Conservative treatment is only abandoned if improvement does not show itself after a thorough trial, or if the disease relapses after apparent cure.

Operative Treatment.—The indications for operative interference vary in different cases. Other things being equal, operation is more often performed in adults than in children, because after the age of twenty there is less prospect of spontaneous recovery, there is more tendency to relapse and for the tuberculous disease to invade the internal organs, and there is no fear of interfering with the growth of the bones. The state of the general health may necessitate operation as the most rapid method of removing the disease. The social status of the patient must be taken into account. The bread-winner, under existing social conditions, may be unable to give up his work for a sufficient time to give conservative measures a fair trial, and the children of the poor cannot always obtain the necessary attention.

The *local conditions* which decide for or against operation are differently regarded by different surgeons, but it may be said in general terms that operative interference is indicated in cases where the disease continues to progress in spite of a fair trial of conservative measures; in cases unsuited for conservative treatment—that is to say, where there is dislocation, separation of epiphysis, or deformity incapable of being otherwise rectified; where there are sinuses with septic infection, and operation affords a reasonable prospect of getting rid of both the tuberculosis and the sepsis; and where the disease is associated with severe bone lesions or with infection of the lymphatics. Operative interference is also indicated in cases where the result will be as good or better than that likely to be obtained by conservative measures, as is often the case in the knee and elbow.

The nature of the operative interference varies with the patient, the joint affected, and the type and extent of the disease. In many cases it can only be decided after exploration of the joint. The aim is to remove all the disease with the least possible impairment of function and the minimum sacrifice of healthy tissue. The more open the method of operating the better, so that all parts of the joint may be available for inspection. Such methods of operating as permit of dislocating the joint are especially to be recommended, since this procedure affords the freest possible access for inspection and for removal of the disease. Cold abscesses should, if possible, be cured before operating on the joint. Diseased synovial membrane is removed with the scissors or knife. If the cartilages are sound, and if a movable joint is aimed at, they may be left; but if ankylosis is desired they must be removed. If there is localised disease of the cartilage the affected portion should be removed, so as to permit of the bone beneath being investigated. If extensively diseased it should be entirely removed, and special attention directed to the bones. If the surface bone is diseased, a thin slice should be removed with the knife or saw. If foci are then revealed in the interior, it is often better to dig them out than to remove further slices of bone, as this involves needless sacrifice of the cortex and periosteum.

The limb should be rendered bloodless before commencing the operation. The technique should be antiseptic rather than aseptic, so as to diminish the chances of tuberculous infection of the wounded surfaces. With the same object, as well as to overcome any minute tuberculous foci which may have escaped detection, a small quantity of sterilised iodoform may be rubbed into the raw surfaces and recesses of the joint. Further details belong to the surgery of the individual joints.

While closure of the entire wound without drainage may be successful, it is safer to employ some means for preventing the accumulation of blood-clot, as this affords an admirable soil for the development of any tubercle bacilli which may have been left behind.

The terms *arthrectomy* and *excision* are those usually applied to the operations performed for the removal of tuberculous disease in any joint. Arthrectomy implies the removal of such synovial membrane and articular cartilage as are diseased, while excision implies the removal of a portion of one or of both of the bones entering into the joint along with the entire synovial membrane and cartilage. It should be stated, however, that the original distinction between these procedures has largely disappeared. The modern operation for the cure of tuberculous joint disease sometimes partakes of the characters of an arthrectomy, sometimes of an excision, but in many cases neither of these terms would accurately describe the operation which best meets the requirements of the case. A formal excision is more often employed in the knee and elbow than in other joints—modified in the case of children, in view of the functional importance of the epiphysial junctions concerned.

It is essential that cases subjected to operation should be kept under supervision for several years, in case of relapse of the disease, to ensure movements of the joint being carried out when the joint is intended to be movable, and to prevent deformities and abnormal attitudes when it is intended to be rigid. Massage, douching, electricity, and exercises promote the recovery of function. When the patient is able to resume the use of the limb, the wasting of muscles and the retardation of the growth of the limb are likely to be recovered from.

Treatment of deformities resulting from tuberculous joint disease by operation has almost entirely replaced the former attempts by forcible reduction. The contracted soft parts are divided, and the bone is divided or resected where there is undesirable osseous ankylosis.

The treatment of relapse or recrudescence is carried out on the same lines as for the original disease, and should be had recourse to as soon as it is recognised.

Amputation of a limb for tuberculous joint disease is becoming one of the rare operations in surgery. It is only employed where recovery is otherwise hopeless. The general health and age of the patient and the occurrence of local and general septic complications are the chief determining factors. Amputation should never be performed unless it secures a complete removal of the disease both in the bones and in the soft parts. Other things being equal, there is less hesitation in having recourse to amputation in the lower than in the upper limb.

SYPHILITIC DISEASES OF JOINTS.

Although comparatively rare, it is probable that the frequency of syphilitic affections of joints has been underestimated, many cases being incorrectly diagnosed. As in tuberculosis, they may occur primarily in the joint structures, or may be secondary to disease in one of the adjacent bones.

In acquired syphilis joint affections may occur during the secondary or tertiary period of the disease.

In the *secondary* stage the disease may assume the form of an *arthralgia*—corresponding to the bone pains—affecting the shoulder, knee, wrist, or ankle. The joint becomes sensitive and painful, the pain being worst at night.

In other cases it assumes the form of a *serous synovitis*—sometimes called syphilitic rheumatism, from its resemblance to poly-articular rheumatism. The joint becomes swollen, hot, and painful, and there may be a certain amount of fever. A chronic effusion or hydrops is met with almost exclusively in the knee; it is frequently bilateral, and is very insidious in its onset and progress, the patient usually being able to go about. Both the synovitis and the hydrops may closely resemble the corresponding lesions resulting from gonorrhœa. They rapidly and completely disappear, however, under anti-syphilitic treatment.

The later or tertiary lesions of joints are more persistent and destructive. They result from the formation of gummata, either in the deeper layers of the synovial membrane, or in the adjacent bone or periosteum. In the majority of cases severe joint symptoms do not develop, unless as a result of breaking down of the gummatous tissue and the addition of septic infection.

Peri-synovial and peri-bursal gummata are most often met with in relation to the knee-joint of adults of middle age, especially females. The gummata are usually multiple; they develop very slowly, and may be unattended with symptoms; they are rarely sensitive or painful. The patient may not apply for advice until the gumma has broken down and given rise to a tertiary ulcer. The simultaneous presence of indolent swellings, ulcers, and depressed scars over the knee-joint is very characteristic of syphilis. When the gummata do not break down, the resemblance to white swelling may be considerable. Attention should be directed to the nodular, uneven, irregular character of the gummatous affection. Sometimes the skin is red and tender over a gumma, without the decided liquefaction and fluctuation which are associated with reddening of the skin in a tuberculous lesion. Recovery may be attended with stiffness and contracture deformity.

Gummata in the periosteum or marrow of the adjacent bones may result in a form of joint disease known as *syphilitic osteo-arthritis*. There is a gradual enlargement of one or other of the bones, attended with pains, which are worst at night. At this stage the diagnosis from sarcoma may be difficult or impossible. The gummatous disease may extend to the synovial membrane and be attended with effusion into the joint, or it may erupt on the periosteal surface and invade the skin, forming one or more sinuses. The further progress in untreated cases is complicated by the occurrence of pyogenic infection and necrosis of bone. In the knee-joint the patella, or one of the condyles of the femur or tibia, may furnish a sequestrum, which, by involving the articular surface, imparts to the disease a persistent character. In such cases anti-syphilitic treatment must be supplemented by operative measures directed to the removal of the diseased tissues. In the case of the knee excision is rarely called for; but in the elbow it may be performed in order to obtain a movable joint.

In inherited syphilis the earliest joint affections are associated with the epiphysitis of young infants. There may be an effusion into the adjacent joint, especially in the knee or elbow; and in exceptional cases pyogenic infection may be superadded, and pus form in the joint. In children, a serous synovitis or hydrops may develop in the knee of one or both sides, sometimes in the earlier period along with iritis, sometimes at a later period along with interstitial keratitis. It is very chronic, scarcely causes any symptoms, and disappears under treatment without impairment of the functions of the joint. The tertiary or gummatous joint lesions in inherited syphilis are the same as have been described in the acquired disease.

JOINT DISEASES ACCOMPANYING CERTAIN CONSTITUTIONAL CONDITIONS.

Gout—*Arthritis Urica.*—Gout is a constitutional disease in which the joints are liable to be attacked with inflammation associated with the deposit of urate of soda. The characteristic lesion is the presence in the joint structures of a chalk-like material composed of sodium bi-urate. This is chiefly observed in the articular cartilage, either in streaks or patches towards the central area of the joint, or over the entire extent of the cartilage, which appears as if it had been painted over with plaster of Paris. The urates are really deposited in the substance of the cartilage, and not on its free surface. The superficial layer is at first intact, but is liable to degenerate and necrose, forming what is known as a gouty ulcer, which may extend deeply into the substance of the bone. The deposit of urates in the synovial membrane is usually attended with effusion into the joint. In the ligaments and tissues around the joint the deposit of urates leads to the overgrowth of fibrous tissue and the formation of adhesions. The metatarso-phalangeal joint of the great toe on one or both sides is that most frequently affected.

The other joints of the foot, the fingers, wrist, ankle, and knee may be also attacked.

The *clinical features* are very characteristic. There is a sudden onset, during the early hours of the morning, of excruciating pain, the joint becoming swollen, red, and puffy, with engorgement of the veins. The first attack may be completely recovered from, but with repeated outbreaks the joint undergoes permanent alterations, becoming stiff, deformed, and in some cases ankylosed. The hands or feet may become seriously crippled, especially when the tendon sheaths and bursæ also are affected (Fig. 209).

The local *treatment* consists in applying soothing applications to the affected joint while the symptoms are acute; later—massage, douching and movement are indicated. Constitutional treatment must also be employed, and a visit to one of the reputed spas is beneficial.

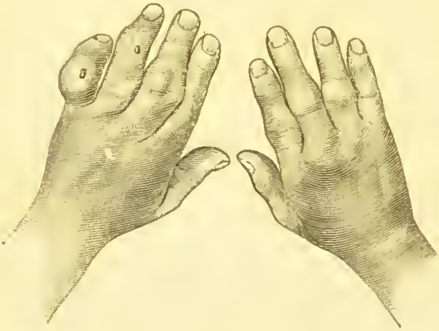

Fig. 209.—Gouty Arthritis of Joints of Fingers with chalk stones.

Chronic Rheumatism.—This term is applied to an ill-defined affection of joints which is remarkable for the amount of suffering to which it may give rise, and the great disturbance in the functions of the joint which may result from it. Its claims to be called rheumatic rest upon the following facts:—That it often follows upon acute articular rheumatism; that it may show exacerbations or relapses which are attended with pyrexia and are relieved by salicylates; that it is met with in patients who present a family history of acute rheumatism or inflammation of serous membranes; and that there may be a history of chorea, erythema nodosum, rheumatic nodules, or other evidences of rheumatism.

It is usually poly-articular. It may be met with in childhood and youth as well as in adult life. The primary changes in the affected joints almost exclusively involve the synovial membrane, the ligaments, the surrounding tendon sheaths, and bursæ. They consist in cellular infiltration and exudation, resulting in the formation of new connective tissue, which encroaches on the cavity of the joint and gives rise to adhesions. This newly formed connective tissue tends to contract, causing deformity and stiffness. The articular cartilages may be transformed into connective tissue with consequent fibrous ankylosis. The bones are only affected in so far as they undergo fatty atrophy, or alteration in their configuration as a result of partial dislocation. Osseous ankylosis may be observed, especially in the small joints of the hand and foot.

Clinically, the disease is chronic and usually incurable. Pain may be so prominent a feature that the patient resists the least attempt at movement. In other cases the joints, although stiff, may be moved and exhibit pronounced crackings. The joints are swollen when there is much new connective tissue formed in relation to the synovial membrane, the swelling becoming more noticeable as the muscles waste above and below the joint. Subacute exacerbations occur from time to time, with fever and aggravation of the local symptoms. Recovery may take place with ankylosis and deformity, the patient becoming a helpless cripple, and the tenure of life is very uncertain because of the tendency to visceral complications.

From the nature of the disease *treatment* is for the most part palliative. Salicylates are only of service during the exacerbations attended with pyrexia. The application of soda fomentations, turpentine cloths, or blisters may be useful. Improvement may result from the general and local therapeutics available at such places as Bath, Buxton, Wiesbaden, Wildbad, or Aix. In selected cases a certain measure of success has followed operative interference, consisting in a modified arthrectomy, and the injection of an emulsion of iodoform or guaiacol in glycerin. The deformities resulting from chronic rheumatism are but little amenable to surgical treatment, and forcible attempts to remedy stiffness or deformity are to be avoided.

Arthritis Deformans or Osteo-Arthritis (*Chronic Rheumatic Arthritis*, *Rheumatoid Arthritis*, *Rheumatic Gout*, *Malum Senile*, *Traumatic or Mechanical Arthritis*).—Under the term arthritis deformans or osteo-arthritis are provisionally included a number of joint affections which in their etiology and clinical features differ widely from one another. Their inclusion in a common group can only be justified by confessing that we are ignorant of their essential nature. In the above list of synonyms, therefore, we must be especially cautious in the use of those names which seem to indicate the origin of the disease. While these affections occur more commonly in families with rheumatic or gouty tendencies, and while they may be preceded by attacks of rheumatism or gout, it is by no means certain that they are of a rheumatic or gouty nature.

The term malum senile—implying, as it does, an association with the changes resulting from advancing years—is singularly inappropriate as applied to a disease which may be met with in childhood. Arbuthnot Lane's suggestion that the lesions under consideration are the result of trauma, while ingenious and instructive, can scarcely be accepted as applicable to all cases. It is easier, however, to express negative opinions in regard to arthritis deformans than to formulate positive views which are of real value.

Morbid Anatomy.—The articular cartilage at first presents a fibrillated appearance. Being of feeble vitality, it is gradually worn away as a result of the movements of the joint until the subjacent bone is exposed. At the margins of the articular surfaces, where the synovial membrane and cartilage meet, there is an active proliferation of cartilage, resulting in nodular projections—*ecchondroses*—which have been compared to the droppings from a candle. These tend to be converted into bone, and the ossification thus started may extend into the capsular ligament, thereby adding to the articular margins a collar or "lip" of new bone, and also into other ligaments and into the insertions of tendons, giving rise to outgrowths of bone — osteophytes or spurious exostoses (Fig. 210).

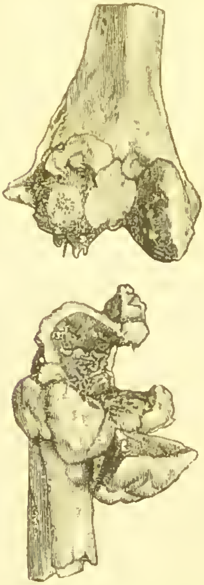

FIG. 210.—Arthritis Deformans of Elbow.

(Anatomical Museum, University of Edinburgh.)

The changes which take place within the articular area subsequent to the disappearance of the cartilage vary in different types of the disease. When rarefaction of bone is the predominant feature, the enlarged medullary spaces are opened into by the wearing away of the surface layer, and the bone then presents an erroded, worm-eaten appearance. In the course of time there may be considerable disappearance of bone and consequent alteration in shape and size,—a change which is well illustrated in the progressive enlargement of the acetabulum which takes place in certain cases of arthritis deformans of the hip. On the other hand, when the bone is condensed and sclerosed, it becomes smooth and polished as a result of the movements of the joint. When this change is very pronounced the appearance may be like that of ivory or porcelain; it is often described as "eburnation" of the articular surfaces. In hinge joints, such as the knee or elbow, the eburnated articular surfaces may present a series of

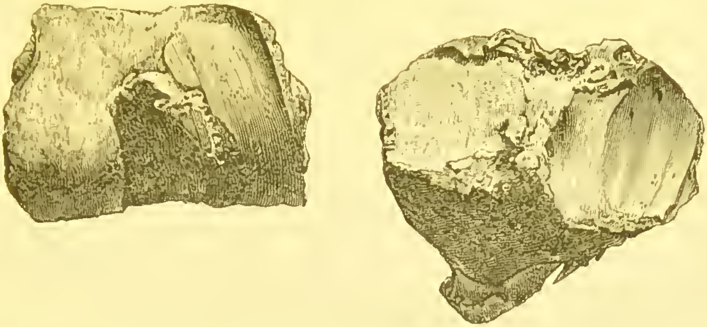

FIG. 211.—Arthritis Deformans of Knee, showing eburnation and grooving of articular surfaces.

(Anatomical Museum, University of Edinburgh.)

parallel grooves corresponding to the lines of movement (Fig. 211). The polishing of the surfaces is in inverse ratio to the pain experienced by the patient.

Although the joint may become locked by the amount of new bone formed around the articular margins, fibrous or bony ankylosis scarcely ever occurs.

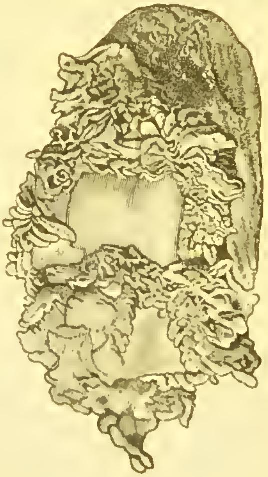

FIG. 212.—Hypertrophied Fringes of Synovial Membrane in Arthritis Deformans of Knee.

(Museum of Royal College of Surgeons, Edinburgh.)

The changes in the synovial membrane vary in different types of the disease. In some cases it merely undergoes a degenerative alteration into cicatricial tissue with a marked tendency to contraction —*arthritis sicca.* In other cases it actively participates in the proliferative changes, becoming more vascular and thickened; and, as the result of hypertrophy of its fringes and enlargement and subdivision of its villi, becomes thickly set with elongated or club-shaped processes which hang into the cavity of the joint (Fig. 212). The term *arborescent lipoma* is applied to the condition when fringes composed of fat are developed to an exaggerated degree. Individual fringes may undergo special enlargement, and form pendulous growths in the interior of which cartilage and bone may be formed; these may attain the size of a hazel-nut or even of a walnut. Whether remaining attached to the synovial membrane by their pedicles, or detached and free in the joint, they may give rise to symptoms of loose body. When the synovial changes are prominent, there is usually considerable serous effusion into the joint, constituting one form of hydrops.

The capsular ligament, except in cases of hydrops, becomes the seat of connective-tissue overgrowth, and tends to become contracted and rigid. Intra-articular ligaments, such as the ligamentum teres in the hip, are usually worn away and disappear. The surrounding muscles become atrophied, tendons become adherent to their sheaths and may become ossified, and nerves may be involved by the cicatricial changes in the tissues surrounding them.

The series of morbid changes, of which the above is a brief summary, may be described as presenting a remarkable combination of degeneration on the one hand, and of overgrowth on the other, suggesting a profound disturbance of nutrition, the cause or causes of which are at present unknown.

The *clinical features* vary widely. *Hydrops* is frequent in the knee, and may be met with in the elbow, shoulder, and ankle. The patient complains of a feeling of weight, of insecurity, and of tiredness in the joint. Pain is occasional and evanescent, and is usually the result of some extra exertion or exposure to cold and wet. As the joint becomes distended with fluid the ligaments are stretched, so that the limb becomes weak and unstable. It may be associated with hydrops of the adjacent bursæ. The affection is extremely chronic, and may last for an indefinite number of years. It is to be diagnosed from the other forms of hydrops already considered,—the purely traumatic, the pyogenic, gonorrhœal, tuberculous, and syphilitic,—and from that associated with Charcot's disease.

Great benefit may follow the withdrawal of the fluid and the injection of iodoform glycerin. The symptoms may be relieved by douching and massage, and by the support of an elastic bandage.

Fringes and pendunculated or loose bodies may give rise to characteristic clinical features, especially in the case of the knee. The fringes, especially when they assume the luxuriance of what has been described as the arborescent lipoma, project into the cavity of the joint, and may fill up its recesses and distend its capsule. The joint is swollen and slightly flexed. Pain is not a prominent feature, the functions of the joint are but little impaired, and the patient may walk fairly well. On grasping the joint while it is flexed and extended by the patient, the fringes may be felt moving under the fingers.

The patient may first apply for advice on account of the symptoms of loose body. The treatment applicable to this type is the removal of the hypertrophied fringes or of the loose body by open arthrotomy, and is usually successful.

The dry form of arthritis deformans (arthritis sicca), although especially common in the knee, is met with frequently in other joints, either as a mon-articular or poly-articular disease; and it is also very common in the joints of the spine and of the fingers, as well as in the temporo-maxillary joint. In the joints of the fingers in older patients the disease is remarkably symmetrical, and tends to assume a nodular type (Heberden's nodes) (Fig. 213); whereas in younger individuals it assumes a more crippling, painful, and progressive fusiform type (Fig. 214). In the larger joints the subjective symptoms usually precede any palpable evidence of disease. The patient complains of stiffness, crackings, and aching, aggravated by changes in the weather and by rest. The roughness due to fibrillation of the articular cartilages may be appreciated by coarse friction on movement of the joint. It may be many months or years before the lipping and other hypertrophic changes in the ends of the bones are recognisable, and before the joint assumes the deformed features which have given the disease its name. These are referred to under the individual joints.

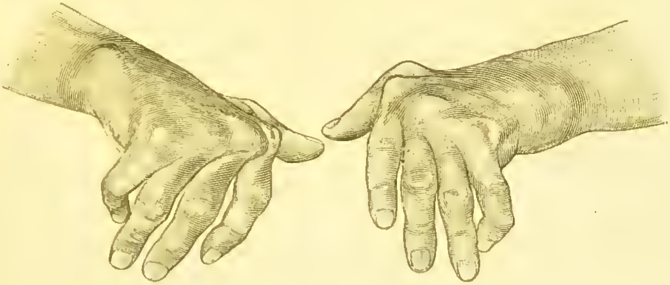

Fig. 213.—Arthritis Deformans of Hands, showing symmetry of lesions, ulnar deviation of fingers, and nodular thickening at interphalangeal joints.

As regards the progress of the disease, it is usually observed that in patients who are still young its tendency is to advance with considerable rapidity, so that in the course of a few months it may cause serious crippling of several joints. In older patients its progress is much more gradual. The disease is quite compatible with long life.

Treatment.—In the absence of definite knowledge of the etiology of the disease, the treatment is chiefly directed towards the relief of symptoms. On no account should the affected joints be kept at rest. Passive movements, exercises of all kinds, massage, hot-air baths, and douching are to be steadily persevered with. When pain is a prominent feature it may be relieved either by douches of iodine and hot water (tincture of iodine 1 oz. to the quart), or by the application of lint saturated with a lotion made up of chloral hydrate, gr. v., glycerine ʒj., water ℥j., and covered with oil-silk. Operative interference by arthrectomy, arthrodesis, or excision is only indicated in large joints when the disease is of an aggravated type, when it is monarticular, and when the general condition of the patient is otherwise favourable.

A course of treatment at one of the reputed spas—Aix, Bath, Buxton, Gastein, Wiesbaden, Wildbad—is often of great service.

The patient should be well nourished, and there need be no restriction in the diet such as is required in gouty patients, so long as the digestion is not impaired. Benefit is also derived from the administration of cod-liver oil and of tonics, such as strychnine, arsenic, and iron, and in some cases of iodide of potassium.

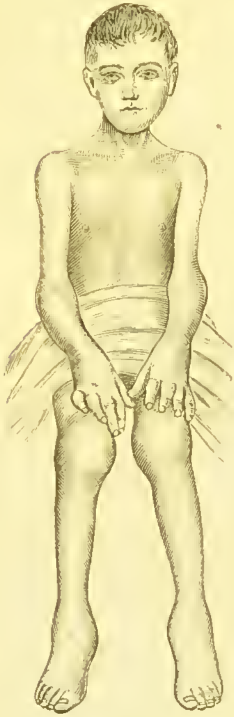

FIG. 214.—Arthritis Deformans affecting several Joints, in a boy aet. 10.

(Dr. Dickson's case.)

Hæmophylia, Hæmarthrosis, Bleeder's Joint.—This is a rare but characteristic affection, chiefly met with in the knee-joint of boys and young adult males who are the subjects of the hæmorrhagic diathesis. The first hæmorrhage into the joint originates suddenly after some trivial injury or without apparent cause. The appearances resemble those of a moderate hydrops; there is little or no pain, and the patient is usually anæmic. The temperature is often elevated (101°, 102° F.), especially if at the same time there are hæmorrhages into the cellular tissue of the limb or elsewhere in the body. The presence of ecchymoses or swellings apart from the joint affected are of great assistance in diagnosis. After a single hæmorrhage into the joint the blood is usually reabsorbed.

After repeated hæmorrhages the joint becomes uniformly swollen from the deposit and subsequent organisation of fibrin on the synovial membrane. As the swelling of the joint is associated with wasting of muscles, flexion, and stiffness, the resemblance to white swelling is very close—so much so, indeed, that a mistake in diagnosis has been made and the joint subjected to operation with disastrous results. The treatment in the case of a recent hæmorrhage consists in absolute rest, the application of cold, and of elastic compression. After an interval, measures should be adopted to promote the absorption of blood and the prevention of stiffness and flexion; these include gentle massage, passive movements, and extension with the weight and pulley. Chloride of calcium may be administered internally with the object of preventing a recurrence of the hæmorrhage.

JOINT DISEASES ASSOCIATED WITH LESIONS OF THE NERVOUS SYSTEM: NEURO-ARTHROPATHIES; SPINAL ARTHROPATHIES; CHARCOT'S DISEASE.

In the absence of any proof of the existence of special trophic nerves distributed to joints, the diseases under consideration are to be regarded as related to a disturbance of the sensory nerves which pass from the joints to the spinal cord, whereby they are cut off from the reflex vasomotor influence which is necessary for their proper nutrition and for their capacity of recuperating from the effects of injury. The joints present a diminished resistance to trauma and other external influences, very similar to that exhibited by the skin in its liability to pressure sores, perforating ulcer, and other trophic disturbances. It may be said, therefore, that while the nerve lesion prepares the way for the joint disease, its onset and progress are largely dependent upon external factors, of which trauma is the most important.

Lesions of the Peripheral Nerves.—In the hand, and more rarely in the foot, when one or other of the main nerve trunks has been divided or compressed, the joints become swollen and painful, and may afterwards become stiff and deformed. Bony ankylosis has been observed in exceptional cases.

Joint lesions are very rare in *affections of the spinal cord*, such as myelitis, progressive muscular atrophy, infantile paralysis, insular sclerosis, and in traumatic lesions, but are not uncommon in locomotor ataxia and syringomyelia.

The occurrence of joint lesions in *locomotor ataxia* (tabes dorsalis) was first described by Charcot—hence the term

"Charcot's disease." Although usually developing in the ataxic stage one or more years after the initial spinal symptoms, they may appear before there is any other evidence of tabes. The onset is frequently determined by some injury to the joint. The joints of the lower extremity are most commonly affected, and the disease is bilateral in a considerable proportion of cases—both knees or both hips, for instance, being implicated.

The disease may assume a mild form in which the joint and its vicinity become swollen, either spontaneously or after some extra exertion or slight injury. The swelling is chiefly due to fluid within the joint, and there is cracking or grating on movement. The affection may disappear under rest, may persist or relapse, or it may merge gradually into the more severe form.

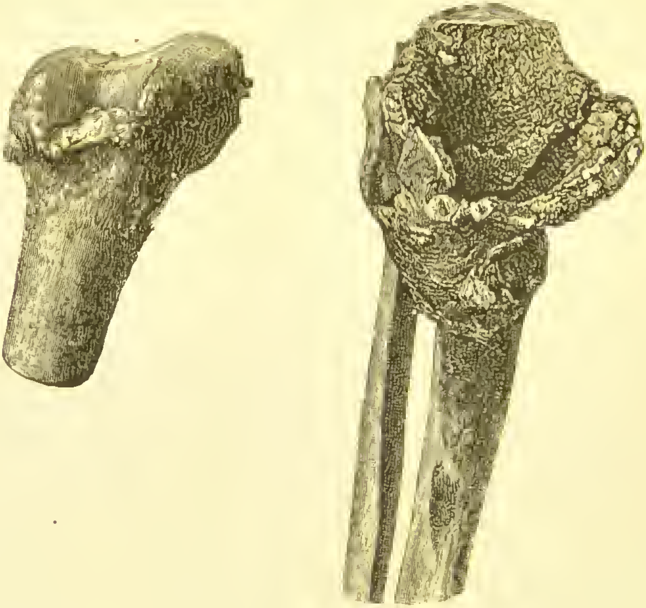

Fig. 215.—Bones of Knee-joint in advanced stage of Charcot's Disease.

(Anatomical Museum, University of Edinburgh.)

In the severe form the onset of the disease is often extremely rapid, so that within a few days the entire joint is disorganised. An atrophic and a hypertrophic type are distinguished according to whether the wearing away and disappearance of bone, or the exaggerated formation of new bone is the more prominent feature (Fig. 215). Sometimes, and especially in the knee, the clinical features are those of an enormous hydrops with fibrinous and other loose bodies and hypertrophied fringes—

like an exaggeration of that met with in arthritis deformans, only there is usually great œdema of the peri-articular tissues (Fig. 216). The joint is wobbly or flail-like from the stretching and destruction of the controlling ligaments, and there is no sensation in it. In other cases the wearing down and total disappearance of the ends of the bones is the prominent feature, this being also attended with flail-like movements and with coarse grating of the opposed surfaces. Dislocation is chiefly observed at the hip (Fig. 229). It is rather a gross displacement with exaggerated mobility than an ordinary dislocation, and it is usually possible to move the bones freely upon one another. An occasional and very striking feature is the extensive formation of new bone in the capsular ligament and surrounding muscles, resulting in the presence of large masses and plates which may add materially to the already-existing deformity of the joint. In certain cases the enormous swelling and its rapid development may suggest the growth of a malignant tumour. The most useful factors in diagnosis are the entire absence of pain, of tenderness, and of common sensibility. The freedom with which a tabetic patient will allow his disorganised joint to be handled requires to be seen to be appreciated.

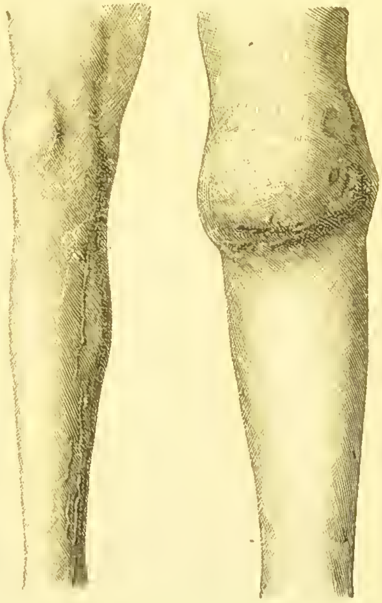

FIG. 216.—Charcot's Disease of Left Knee. The joint is distended with fluid.

In syringomyelia joint affections ("gliomatous arthropathies") are more frequent than in tabes, and they usually involve the upper extremities in correspondence with the seat of the spinal lesion, which chiefly affects the lower cervical and upper dorsal segments of the cord (Fig. 219). Except that the joint disease is rarely symmetrical, it closely resembles the arthropathy of tabes. The completeness of the analgesia of the joint structures and of the overlying soft parts is well illustrated by the fact that the joint has been painlessly excised without an anæsthetic, and that in one case the patient himself was in the habit of evacuating the fluid from his elbow with the aid of a pair of scissors.

Suppuration, apart from superadded infection through a breach of the surface, does not occur in any of the forms of spinal arthropathy.

Pathological fracture may occur as a complication both in tabes and in syringomyelia.

The prognosis is uncertain, as the disease may go on to complete disorganisation of the joint, or it may become arrested, in which case the limb may retain its functions to a greater or less extent.

Treatment is usually directed towards retarding or arresting the progress of the disease by supporting and protecting the joint by means of bandages, splints, and special apparatus. In the lower extremity the use of crutches may assist in taking the strain off the affected limb. When there is much distension of the joint considerable relief may follow evacuation of the fluid. The best possible result being rigid ankylosis in a good position, it may be advisable to bring this about artificially by arthrodesis or excision, where only one joint is affected, and where the cord lesion is such as will permit of the patient moving about. Although the victims of tabes are unfavourable subjects for operative interference on account of their liability to intercurrent complications, the wounds heal remarkably well. When the limb is quite useless, and there is danger from superadded pyogenic infection, amputation may be necessary.

In cerebral lesions attended with hemiplegia, joint affections, characterised by evanescent pain, redness, and swelling, are occasionally met with in the paralysed limbs. The secondary changes in joints which are the seat of paralytic contractnre are considered elsewhere.

An intermittent neuropathic hydrops has been observed—especially in the knee—in cases of epilepsy, hysteria, and general paralysis of the insane, but it is of little clinical importance.

HYSTERICAL OR MIMETIC JOINT AFFECTIONS.

Under this heading Sir Benjamin Brodie in 1822 described an affection, characterised by the prominence of subjective symptoms, and the absence of any pathological changes in the joint. Although chiefly met with in young women with an impressionable nervous system, and especially among those in good social circumstances, it occurs occasionally in men. The onset may be referred to injury or exposure to cold, or it may be associated with some disturbance of the emotions or of the generative organs, or may result from an involuntary imitation of the symptoms of organic joint disease presented by another patient.

It is characteristic that the features develop abruptly without sufficient cause, that they are exaggerated and wanting in harmony with one another, and that they do not correspond with the typical features of any of the known forms of organic disease. In some cases the only complaint is of severe neuralgic pains; more often these are associated with excessive tenderness, and with impairment of the functions of the joint. On examination the joint presents a normal appearance, but the skin over it is remarkably sensitive. A light touch is more likely to excite pain than deep and firm pressure. Stiffness is a variable feature—in some cases amounting to absolute rigidity, so that no ordinary force will elicit movement. It is characteristic of this, as of other neuroses, that the symptoms come and go without apparent cause. When the patient's attention is diverted, the pain and stiffness may disappear. There is never any actual swelling of the joint, although there may be an appearance of this from wasting of the muscles above and below. If the joint is kept rigid for long periods, secondary contracture may occur—in the knee with flexion, in the hip with flexion and adduction. Attempts at movement may then cause cracking. Months or even years may elapse without any further developments taking place.

The *diagnosis* is often a matter of considerable difficulty, and the condition must not be mistaken for such organic lesions as a tuberculous or pyogenic focus in the bone close to a joint, which may cause vague neuralgic pains for long periods before rupturing into the articulation. Examination of the joint under chloroform or the use of the Röntgen rays may assist in difficult cases, but it is on record that an experienced surgeon has been obliged to perform an exploratory operation in order to make a definite diagnosis. The greatest difficulty is met with in the knee and hip, where the condition may closely simulate tuberculous disease.

The *local treatment* consists chiefly in improving the nutrition of the affected limb by means of massage, baths, and electricity. Splints are to be avoided. In refractory cases considerable benefit may follow the application of Corrigan's button or the actual cautery. The general condition of the patient must be treated on the same lines as in other neuroses. The Weir-Mitchell treatment may prove of great service. It consists in secluding the patient from her friends and relatives, placing her in charge of a nurse, and paying special attention to feeding. Complete recovery is the rule.

Tumours and Cysts.

Innocent tumours of the synovial membrane are rarely recognised as distinct from the overgrowths which occur in chronic forms of joint disease, such as arthritis deformans.

Sarcoma of the synovial membrane has been met with chiefly in the knee, and has nearly always been mistaken for synovial tuberculosis. Cases are recorded in which a localised sarcoma of the synovial membrane has given rise to the symptoms of loose body. The treatment consists in free removal of the infected tissues.

Cysts of joints constitute an ill-defined group which includes ganglia formed in relation to the capsular ligament. Cystic distension of bursæ which communicate with the joint is most often met with in relation to the knee in cases of long-standing hydrops. It has been maintained that similar cystic swellings may result from the hernial protrusion of the synovial membrane between the stretched fibres of the capsular ligament, and the name "Baker's cysts" has been applied to these, after Morrant Baker, who first described them.

In the majority of cases cysts in relation to joints give rise to little inconvenience and may be left alone. If interfered with at all they should be excised.

Loose Bodies.

While there is probably no more controversial subject in surgical pathology than the origin and nature of loose bodies in joints, their clinical aspects and treatment are clear and straightforward. It is convenient to group them anatomically into two classes: those composed of fibrin, and those composed of organised connective tissue.

Fibrinous Loose Bodies (corpora oryzoidea).—These are homogeneous or concentrically laminated masses of fibrin, sometimes resembling rice grains, melon seeds, or adhesive wafers, sometimes quite irregular in shape. Usually they are present in large numbers, but sometimes they are solitary and may then attain considerable dimensions. They are not peculiar to joints, for they are met with in tendon sheaths and bursæ, and their origin from synovial membrane may be accepted as proved. They occur in tuberculosis, arthritis deformans, or Charcot's disease, and their presence is almost invariably associated with an effusion of fluid into the joint. While they may result from the coagulation of fibrin-forming elements in the exudation, their occurrence in tuberculous hydrops would appear to be the result of coagulation necrosis or fibrinous degeneration of the surface layer of the diseased synovial membrane. However formed, their shape is the result of mechanical influences, and especially of the movements of the joint.

Clinically, loose bodies composed of fibrin constitute an unimportant addition to the features of the disease with which they are associated. They never give rise to the classical symptoms associated with the impaction of a loose body between the articular ends of the bones. Their presence may be recognised, especially in the knee, by the crepitating sensation imparted to the fingers when the bodies are moved to and fro in the fluid. The *treatment* is directed towards the disease underlying the hydrops. If it is desired, however, to empty the joint, a large trocar and cannula must be employed, otherwise the cannula is liable to become blocked with the bodies. Should this occur the contents of the joint should be evacuated by means of a suitable incision.

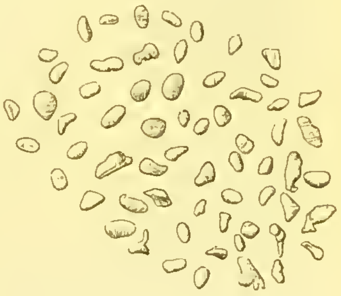

FIG. 217.—Melon-seed Bodies from Tuberculous Knee-joint.

Bodies composed of organised connective tissue—fatty, fibrous, cartilaginous, bony, or combinations of these—are met with either in association with some general disease of the joint or in joints which are otherwise healthy.

Loose bodies composed of connective tissue or of its derivatives are comparatively common in arthritis deformans; they are also met with in certain rare forms of synovial tuberculosis and in Charcot's disease. They result almost exclusively from hypertrophic changes in the synovial fringes. They may consist of fat—for example, the arborescent lipoma; more commonly the connective-tissue cells of the fringes form fibrous tissue, cartilage, and bone in varying proportions and combinations, after the manner commonly observed in innocent new growths (Fig. 218). Like other hypertrophies on a free surface they tend to become polypoidal and pedunculated, and exhibit a limited range of movement. The pedicle or stalk may, however, give way and the body become free. In this condition it may wander about the joint, or lie snugly in one of its recesses until disturbed by some exaggerated movement or twist. In the free state it is alleged to be capable of continued growth, deriving the necessary nutriment from the surrounding fluid.

The size and number of the bodies vary indefinitely. Single specimens have been known to attain the size of the patella. The smaller varieties may number considerably over a hundred. A rarer type of loose body is met with in arthritis deformans, when a portion of the lipping of one of the articular margins is detached by injury. It may also be mentioned that in Charcot's disease large loose bodies composed of bone may be formed in relation to the capsular and other ligaments, and can be made to grate upon one another.

The *clinical features* in this group of organised loose bodies are mainly those of the disease which has given rise to them, and it is exceptional to meet with definite symptoms from impaction of the body between the articular surfaces. Treatment is to be directed towards the primary disease in the joint, as well as to the removal of the loose bodies.

Loose Bodies in Joints which are otherwise Healthy. — These constitute the majority of cases causing the classical symptoms of loose body and calling for operative treatment. They are met with chiefly in the knee and elbow of healthy males under the age of thirty. The complaint may be of vague pains in the joint which are usually ascribed to rheumatism, of occasional cracking on movement, or of impairment of function, and usually an inability to extend or flex the joint completely. In many cases a clear account is obtained of the characteristic symptoms which arise when the body is impacted between the articular or other closely applied surfaces of the joint. These are the sudden onset of intense sickening pain, with loss of power in the limb and locking of the joint, followed by effusion and other accompaniments of a severe sprain. On some movement of the joint the body may be disengaged, the locking disappears, and recovery takes place as after an ordinary sprain or twist. Similar attacks may recur at irregular intervals during a period of many years. On examining the joint it is usually found to contain fluid, and there may be points of special tenderness corresponding to the ligaments which have been sprained. The patient himself

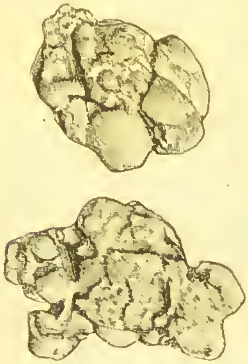

FIG. 218.—Loose Bodies from Knee-joint.

(Anatomical Museum, University of Edinburgh.)

or the surgeon may succeed in palpating the loose body and in making it roll beneath the fingers, especially if it be lodged in the supra-patellar pouch in the knee, or on one or other side of the olecranon in the elbow. In most instances the patient has carefully observed his own symptoms, and is aware not only of the existence of the loose body, but of its situation when attached, or of its erratic appearance at different parts of the joint when free. When the body contains bone it may be visible in a skiagram. While in some cases the patient attributes his symptoms to an injury, exactly similar phenomena may occur apart altogether from traumatic influences. The treatment consists in opening the joint and removing the loose body.

The characters of these loose bodies are remarkably constant. They are usually solitary, about the size of a bean or almond, concavo-convex in shape, the convex aspect being smooth like an articular surface, the concave aspect more often uneven and nodulated. Such bodies when still attached may be lodged in a kind of compartment or excavation in one of the articular surfaces, usually one or other condyle of the femur, from which they may be readily shelled out by means of an elevator. They usually present on section a nucleus or core of spongy bone or of calcified cartilage.

As to the origin of these loose bodies, some maintain that they result entirely from the detachment by injury of a portion of the articular surface, while others regard them as overgrowths derived from the synovial membrane. König regards them as portions of the articular surfaces which have been detached by a morbid process which he calls "osteochondritis dissecans."

In a certain number of cases the appearance and structure of loose bodies would justify the inference that they are of the nature of tumour growths. This is notably the case in the knee-joint, in which cartilaginous or chondro-sarcomatous bodies may be met with similar to the corresponding tumours growing from bones.

Displacement of the semilunar cartilages in the knee is referred to with injuries of that joint.

CHAPTER XXX.

DISEASES OF INDIVIDUAL JOINTS.

THE SHOULDER-JOINT.

DISEASE is rare in the shoulder in comparison with other joints, and as a rule is met with in adults. In young subjects infective processes implicating the joint result chiefly from extension of disease from the upper epiphysial junction of the humerus, which is partly included within the limits of the synovial cavity. The synovial membrane, in addition to lining the capsular ligament, is frequently prolonged down the bicipital groove around the long tendon of the biceps, and pus or other fluid may escape from the joint by means of this diverticulum and gravitate down the upper arm. There is frequently a communication between the joint and the sub-deltoid bursa. There is no characteristic attitude in disease of the shoulder-joint, but the upper arm is usually held close to the side and rotated slightly inwards, while the elbow is carried a little backwards. Fixation of the shoulder-joint is largely compensated for by the free movement of the scapula on the thorax, and even when ankylosis occurs it is not so disabling as in other joints. In testing for rigidity the scapula should be fixed with one hand, while passive movements of the arm are carried out with the other. Swelling is rarely a prominent feature, except when there is a considerable quantity of fluid bulging the deltoid, or when there is an abscess outside the joint. More commonly the deltoid is atrophied, allowing the acromion, coracoid, and great tuberosity of the humerus to stand out prominently beneath the skin.

Tuberculous Disease.—This is chiefly met with in young adults, although it may occur at any age. It is more common in the right shoulder. The prominent features are pain, wasting of muscles, and rigidity. The pain may be severe, shooting down the arm and interfering with sleep, and it may be associated with tenderness on pressure over the upper end of the humerus. The wasting chiefly involves the deltoid and scapular muscles. In cases with advanced carious destruction of the articular surfaces there may be starting pains and the upper arm may be shortened. A cold abscess may form in the bursa underneath the deltoid, and the pus may burrow and appear at the anterior or posterior boundary of the axilla or in the axilla itself. Pus formed in the joint may gravitate along the bicipital groove. The axillary glands may become infected.

The lesion underlying tuberculous disease of the shoulder is either a large caseating focus in one of the bones—more often in the upper end of the humerus—or it is of the nature of caries sicca. The greater part of the head may disappear, and the end of the shaft be drawn upwards against the socket. In exceptional cases, portions of the glenoid or humerus may be found separated as sequestra, or the disease may involve parts outside the joint, such as the acromion or coracoid process. Tuberculous hydrops with melon-seed bodies is very rare. Destruction of the tissues at the ossifying junction in young subjects may result in considerable shortening of the upper arm.

The *diagnosis* is to be made from (1) arthritis deformans, in which the movements are less restricted, and are attended with grating and crackling; (2) paralysis involving the deltoid and scapular muscles—by the absence of pain, and the free, or even flail-like, character of the movements; and (3) disease in the sub-deltoid bursa—by the absence of rigidity and other evidence of implication of the articular surfaces. (4) The diagnosis from sarcoma of the upper end of the humerus may call for the use of the X-rays or of an exploratory incision.

While the *prognosis* is favourable on the whole, spontaneous recovery is usually attended with fibrous ankylosis and incapacity to raise the arm above the level of the shoulder. The disease is often very persistent, and may last for several years.

Treatment.—In the early stages rest is indicated. The limb should be immobilised in a Thomas' splint or plaster of Paris, in the position of abduction with the forearm and hand directed forwards, so as to retain the most useful range of movement in the event of stiffness occurring. Severe pain may be relieved by blistering or by the application of the cautery. To inject iodoform emulsion the needle is introduced either immediately outside the coracoid, or just below the junction of the acromion and spine of the scapula. Cold abscess is treated on the usual lines. Operation should not be delayed in cases which do not yield to conservative measures. Excision of the joint is a very satisfactory operation, and although ankylosis usually occurs, the arm is a useful one.

Pyogenic Diseases.—The shoulder-joint may be infected by extension of suppurative periostitis and osteomyelitis from the upper end of the humerus, or from suppuration in the axilla, or through the blood-stream in pyæmia. typhoid, or gonorrhœa, When it is necessary to drain the joint the incision should be placed anteriorly in the line of the bicipital groove, and a counter-opening made on the posterior aspect by cutting on the point of a dressing forceps introduced through the anterior incision.

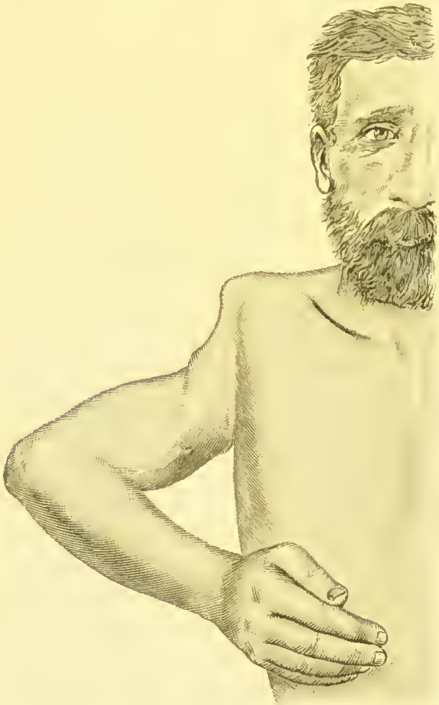

Fig. 219.—Arthropathy of Shoulder in Syringomyelia. The upper end of the humerus had disappeared and the movements were flail-like.

Arthritis Deformans.—The shoulder is seldom the only joint affected, except when the arthritis is a sequel to injury. The common type of lesion is a dry arthritis with fibrillation and subsequent eburnation of the articular surfaces. The long tendon of the biceps is usually destroyed, and the head of the bone may be drawn upwards, and, after wearing through the capsule, rubs on the under surface of the acromion. The prominent clinical features are pain, stiffness, and crackling on movement.

Neuro-arthropathies of the shoulder are chiefly met with in cases of syringomyelia. The clinical features may be a large and painless swelling with fluctuation in the region of the shoulder, or marked and rapid wasting of the deltoid and scapular muscles with flail-like movements of the joint, associated with disappearance of the upper end of the humerus (Fig. 219).

THE ELBOW-JOINT.

In disease of the elbow the usual attitude is that of flexion with pronation of the hand. Swelling of the joint, whether from effusion of fluid or from thickening of the synovial membrane, is chiefly perceived on the posterior aspect, above and on either side of the olecranon, because the synovial sac is here nearest the surface. In relation to disease of the elbow-joint, the free communication between the elbow and the superior radio-ulnar joint should be borne in mind.

Tuberculous disease is the most common and important (Fig. 220). While it usually occurs under twenty, it may be met with at any age, and even in old people. When the disease is confined to the synovial membrane its onset is very insidious. There is little or no pain, and no interference with any movement except complete extension. The only evidence of disease is the development of a white swelling on either side of and above the olecranon, obscuring the bony landmarks. The further progress is attended with wasting of the triceps, symptoms of involvement of the articular surfaces, and with abscess formation. The occurrence of articular caries without swelling of the synovial membrane is exceptional, and is associated with a good deal of pain and considerable restriction of movement. Rigidity from muscular contraction occurs late, and is rarely complete. Tuberculous foci in the bones are chiefly met with in the upper end of the ulna and the lower end of the humerus; they may

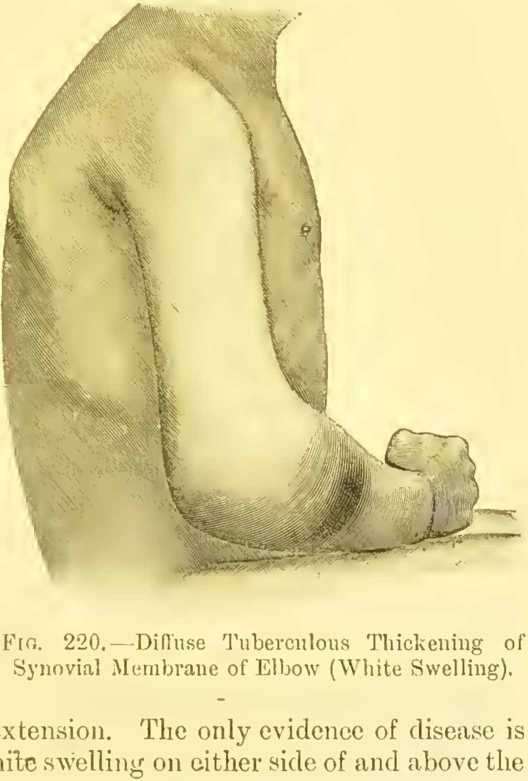

FIG. 220.—Diffuse Tuberculous Thickening of Synovial Membrane of Elbow (White Swelling).

be recognised by swelling and pain on pressure over the bone. The grosser osseous lesions may cause enlargement of the bone, and are readily demonstrated by skiagraphy. Abscess formation most commonly occurs beneath the triceps, and the abscess points at one or other margin of that muscle. A subcutaneous abscess may form over the upper end of the ulna or over the radio-humeral joint. Tuberculous hydrops with melon-seed bodies is rare.

Treatment.—Conservative measures are indicated in cases where there is any prospect of securing a movable joint. The limb is placed in a Thomas', Croft's, or poroplastic splint, flexed to rather less than a right angle and with the hand semi-pronated. If it is decided to inject iodoform emulsion, the needle of the syringe is most easily introduced between the external condyle and the head of the radius. Cold abscess is treated on the usual lines. A localised focus of disease in one or other of the bones may be eradicated without opening into the synovial cavity.

If the articular surfaces are so involved that recovery is likely to be attended with ankylosis, the disease should be removed by arthrectomy or excision without unnecessary delay. Cure of the disease with a useful and movable limb may then be reasonably anticipated within two or three months. It may happen, however, that the patient's occupation is such that a strong, stiff joint is preferable to a weaker movable one.

Arthritis deformans occurs as a hydrops with hypertrophy of the synovial fringes and loose bodies, or as a dry arthritis with eburnation and lipping of the articular margins (Fig. 210).

Neuro-arthropathies are chiefly met with in syringomyelia, and are attended with striking alterations in the shape of the bones and with abnormal mobility.

Pyogenic diseases result from staphylococcal osteomyelitis—chiefly of the humerus or ulna—and from gonorrhœa.

The remaining diseases at the elbow include syphilitic disease in young children, bleeder's joint, hysterical affections, and loose bodies, and do not call for special description.

THE WRIST-JOINT.

The close proximity of the flexor sheaths to the carpal articulations enables infective processes to spread readily from one to the other. The arrangement of the synovial membrane also favours the extension of disease throughout the numerous articulations in the region of the wrist.

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Tuberculous disease is chiefly met with in young adults, but may occur at any age. It usually originates in the synovial membrane, but foci are frequently present in the carpal bones, and less commonly in the lower ends of the radius and ulna, and in the bases of the metacarpals. The clinical features are almost invariably those of white swelling which is most marked on the back of the wrist, where it obscures the outlines of the bones and of the extensor tendons. Wasting of the thenar and hypothenar eminences and filling up of the hollows above and below the anterior annular ligament render the appearance on the palmar aspect very characteristic.

The attitude is one of slight flexion with drooping of the hand and fingers. The fingers become stiff as a result of adhesions in the tendon sheaths, and the power of opposing the thumb and fingers may be lost. Pain is usually absent until the articular surfaces become carious, and it is then aggravated by movement. Softening of the ligaments may result in lateral mobility and sometimes in partial dislocation. Abscess formation is a troublesome complication, as it may result in the formation of sinuses, and in infection of the tendon sheaths, especially of those in the palm.

The exact localisation of disease in individual bones or joints may be determined by the positions of pain elicited on pressure or movement, by the use of the X-rays and by the situation of sinuses.

Treatment.—Conservative measures may be persevered with over a longer period than in most other joints. The forearm, wrist, and metacarpus are immobilised in the attitude of slight dorsal flexion, by means of a poroplastic or metal splint, while the fingers and thumb are left free to allow of passive movements. To inject iodoform emulsion the needle is inserted immediately below the radial or the ulnar styloid process. Sometimes the carpal bones are so soft that the needle may be made to penetrate them in different directions. Abscess is treated on the usual lines. Excision of the diseased bones and synovial membrane is a satisfactory operation, and usually yields a movable joint at the wrist. It is indicated in cases which resist conservative measures and where the general health calls for early removal of the disease.

Other diseases of the wrist are comparatively rare. They include pyogenic affections such as those resulting from septic conditions in the palm of the hand, different types of gonorrhœal, rheumatic, and gouty affections, and arthritis deformans.

THE HIP-JOINT.

Owing to the depth of this joint from the surface it is not possible to detect the presence of effusion or of synovial thickening as readily as we can in other joints, hence in the recognition of hip disease we have to rely very largely upon indirect evidence, such as a limp in walking, an alteration in the attitude of the limb, or restriction of the normal movements of the joint. In examining a case of suspected hip disease it is necessary to compare the lengths of the two limbs, to ascertain the position of the great trochanter in relation to Nélaton's line, to recognise the attitude of the limbs in relation to the pelvis, and to note whether or not the pelvis is tilted.

It should be borne in mind that the whole of the anterior and fully one-half of the posterior aspect of the neck of the femur is covered by synovial membrane, so that not only lesions of the epiphysis and epiphysial junction, but also those in the neck of the bone, are capable of direct extension to the synovial membrane and to the cavity of the joint. Infective material may escape from the joint into the surrounding tissues through any weak point in the capsule, particularly through the bursa which intervenes between the capsule and the ilio-psoas, and which communicates with the joint in one out of every ten subjects.

Tuberculous Disease.—Tuberculous disease of the hip, morbus coxæ, or "hip-joint disease," is especially common in the poorer classes. It is a frequent cause of prolonged invalidism and of permanent deformity, and is attended with a considerable mortality. It is essentially a disease of early life, rarely commencing after puberty, and almost never after maturity.

Pathological Anatomy.—Bone lesions bulk more largely in hip disease than is the case in other joints—five cases originating in bone to one in synovial membrane. The acetabulum and upper end of the femur are affected with about equal frequency. Disease originating in the spongy bone in the floor of the acetabulum may spread into the pelvis, and there give rise to a swelling which may be felt *per rectum.*

In addition to primary tuberculous lesions, secondary changes result from pressure of the inflamed and softened bones against one another, subsequent to the destruction of their articular cartilages. The head of the femur undergoes absorption from above downwards, becoming flattened and truncated, or disappearing altogether. In the acetabulum the absorption takes place in an upward and backward direction, whereby the socket becomes enlarged and elongated towards the dorsum ilii. To this progressive enlargement of the socket Volkmann gave the suggestive name of "wandering acetabulum." These secondary changes are of clinical importance, the resulting displacement of the femur being one of the most important causes of real shortening of the limb in advanced cases of hip disease, especially when untreated.

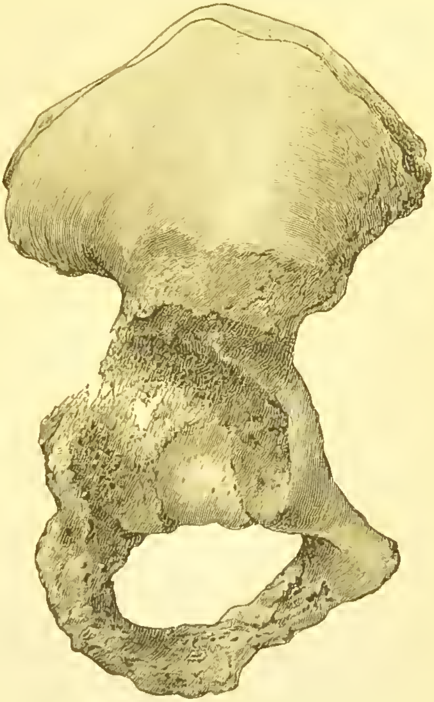

Fig. 221.—Advanced Tuberculous Disease of Acetabulum with Perforation into Pelvis.

(Anatomical Museum, University of Edinburgh.)

Clinical Features.—For convenience of description it is customary to divide these into three stages, which, however, merge into one another. There is usually a well-marked stage of onset characterised by a limp, pain, and restriction of the movements of the joint; a second stage, in which the limb is abducted and apparently lengthened; and a third stage, with adduction and apparent or actual shortening. The first of these stages may be absent, or may escape observation; the second is very typical of hip disease, but may also be absent in cases of an acute type in which the attitude from the outset is one of adduction. Recovery often occurs before the disease reaches the third stage, or the treatment adopted may prevent the limb assuming the attitude characteristic of this stage. The formation of abscess may take place at any stage.

Initial Stage.—At this stage the disease is still confined either to the synovial membrane, or to a focus in the bone which has not yet opened freely into the cavity of the joint. The onset is usually very insidious. If injury is alleged as an exciting cause, some weeks usually elapse between the receipt of the injury and the onset of symptoms. In the case of a child, he is usually brought for advice because he has begun to limp and to suffer pain. The statement may be made that he has become pale, that he has ceased to take food well, that his sleep has been disturbed, and that the pain and the limp, after coming and going for a time, have become more continuous and pronounced. On walking, the affected limb is dragged in such a way as to avoid movement at the hip, and to substitute for it movement of the pelvis. The child throws the weight of the trunk as little as possible on to the affected limb, and inclines to rest on the balls of the toes rather than on the heel. There is usually some wasting of the muscles of the thigh and slight flattening of the buttock. Diminution or loss of the gluteal fold indicates a degree of flexion at the hip which might otherwise escape notice. Pain is complained of in the hip, or shooting down through the obturator nerve to the inner side of the knee. Sometimes the pain is confined to the knee, and if the examination is restricted to that joint the disease at the hip may be overlooked. At this stage the attitude of the limb is not constant; it may be quite natural at one time, and slightly flexed or abducted at another. Tenderness of the joint may be elicited either in front or behind the head of the bone, but is of little diagnostic importance. Pain elicited on driving the head against the acetabulum may occasionally assist in the recognition of hip disease, but the diagnostic value of this sign has been overrated. Most stress is to be laid on testing the functions of the joint, and if this be done gently and without jerking, there is no complaint of pain. To reassure the child the movements should be first practised on the sound limb. The child should lie on his back, either on his nurse's knee or on a table. On slowly flexing the thigh of the affected limb, it will be found that the range of flexion at the hip is soon exhausted, and that any further movement in this direction takes place at the lumbo-sacral junction. The child is next made to lie on his face with the knees flexed in order to test the movements of rotation. The thigh is rotated outwards and inwards, and on comparing the two sides it will be found that rotation is restricted or abolished on the side affected, any apparent rotation taking place at the lumbo-sacral junction. These tests reveal the presence of *rigidity* resulting from the involuntary contraction of muscles, which is the most reliable sign of hip disease during the initial stage. This procedure has the advantage of being universally applicable, even in the case of very young children. If there should still exist any doubt as to the presence of hip disease, the examination should be repeated from week to week until a definite conclusion is arrived at.

Second Stage.—The patient now presents more evident symptoms of hip disease, and usually exhibits the attitude of abduction, eversion, and flexion (Fig. 222). This stage probably corresponds with commencing disease of the articular surfaces and progressive involvement of all the structures of the joint. The attitude described would appear to be the result of muscular action.

The combination of abduction, eversion, and flexion, although characteristic of the second stage of hip disease, is not constant; the proportion of the different elements not only varies in different cases, but one or other element may be wanting.

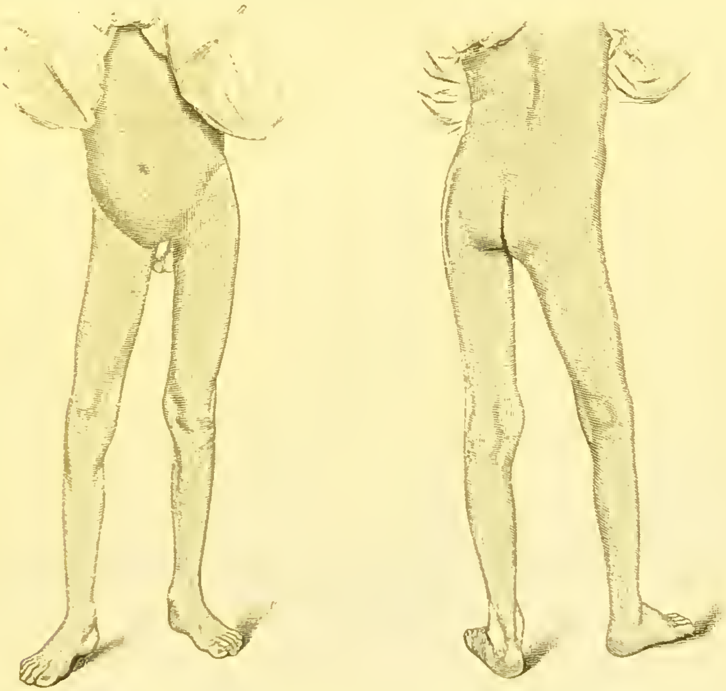

FIG. 222.—Early Tuberculous Disease of Right Hip-joint in a boy æt. 14, showing flexion, abduction, and apparent lengthening of the limb.

The abnormal attitude is at first entirely maintained by the action of muscles; but where it is prolonged, the muscles, fasciæ, and ligaments undergo shortening, so that it becomes permanent, and is continued without muscular effort.

On first looking at the patient the abnormal attitude may be largely concealed, as he usually restores the parallelism of the limbs by lowering the pelvis on the affected side and adducting the sound limb. This obliquity, or tilting of the pelvis, causes *apparent lengthening* of the diseased limb. It is best demonstrated by drawing one straight line between the anterior iliac spines, and another to meet it from the ensiform cartilage through the umbilicus. If the pelvis is in its normal or horizontal position, the two lines intersect one another at right angles; if it is tilted, the angles at the point of intersection are unequal. The flexion of the thigh may be largely compensated for by increasing the forward curve of the lumbar spine (lordosis) and by flexing the leg at the knee. To demonstrate the lordosis the patient should be laid on a flat table; when the thigh is flexed the lumbar spine is in contact with the table (Fig. 223); when the thigh is extended the spine arches forwards so that one may insert the hand or the closed fist beneath it (Fig. 224). There may also be an attempt to compensate for the eversion of the limb by rotating the pelvis forwards on the affected side.

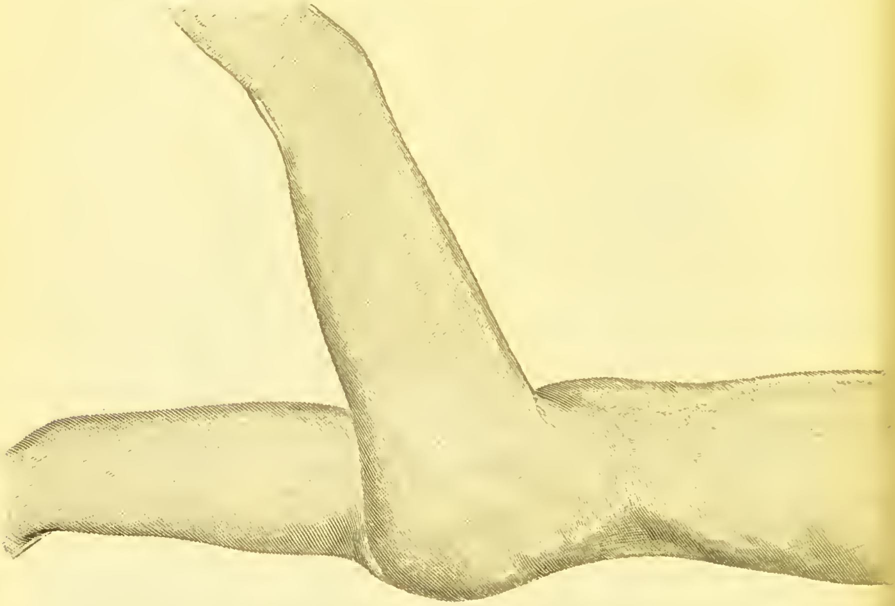

FIG. 223.—Disease of Left Hip—disappearance of lordosis on flexion of the joint.

If *the functions of the joint* are tested, it will be found that there is more or less rigidity, and that both active and passive movements take place at the lumbo-sacral junction instead of at the hip. While rigidity is usually absolute as regards rotation, it may sometimes be possible with care and gentleness to obtain a little increase of flexion. For diagnostic purposes most stress should therefore be laid on the presence or absence of rotation—for example, if a patient exhibits abduction and flexion, while it is possible to elicit rotation movements, the probability is that he is not suffering from disease in the joint, but from some affection in its neighbourhood.

Swelling should be looked for on the anterior aspect of the joint. When present it may fill up the fold of the groin, and project forward the femoral vessels. It is doughy and elastic like the white swelling of other joints, but may at any time liquefy and form a cold abscess. Swelling about the trochanter and neck of the bone may be estimated by measuring with calipers and comparing with the sound side. The absence of swelling does not preclude the existence of grave lesions in the interior of the bone. Swelling on the pelvic aspect of the acetabulum may be discovered on rectal examination.

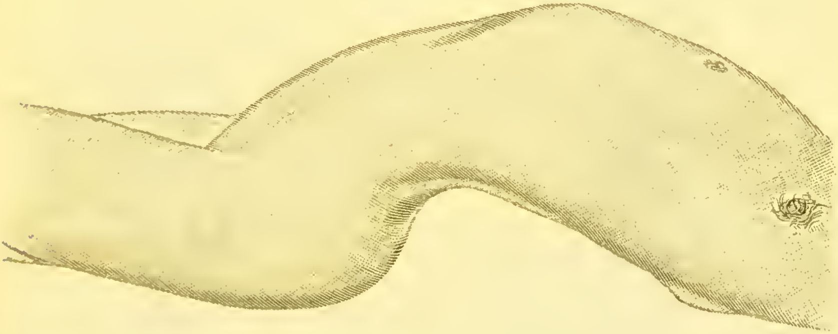

FIG. 224.—Disease of Left Hip—lordosis of spine on extension of the joint.

Third Stage.—The patient now presents unmistakable symptoms of hip disease in the form of *adduction*, *inversion*, *increase of flexion*, and *apparent or real shortening of the limb* (Fig. 225). This probably corresponds with advanced caries of the articular surfaces, since pain is now a more prominent feature, and there are usually startings at night. This stage is not often met with nowadays, because the disease is diagnosed in its earlier stages and appropriate treatment adopted. The *flexion* is usually so pronounced that it can no longer be concealed by lordosis, so that when the patient is recumbent, although the spine is arched forwards, the limb is still flexed both at the hip and at the knee. When the spine is flat on the table the flexion of the thigh may amount to as much as a right angle. The *adduction* varies very much in degree. When moderate in amount it is compensated for by raising the pelvis on the affected side, which results in *apparent shortening* of the limb (Fig. 226). It is of great importance to recognise the cause of this shortening, as it can be prevented by treatment. It is the result of an effort on the part of the patient to restore the normal parallelism of the limbs, the sound limb being abducted to the same extent as the affected limb is adducted. As a result of the obliquity of the pelvis, the patient, when erect, exhibits a lateral curvature of the spine with the dorso-lumbar convexity to the sound side.

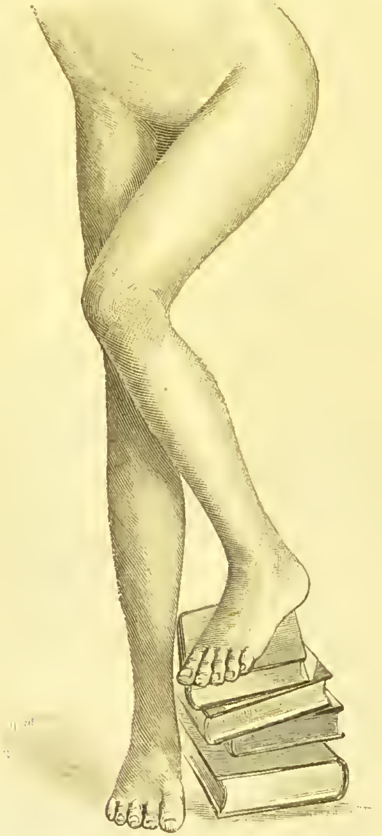

FIG. 225.—Advanced Tuberculous Disease of Left Hip-joint in a girl æt. 7, showing flexion, adduction, inversion, and shortening.

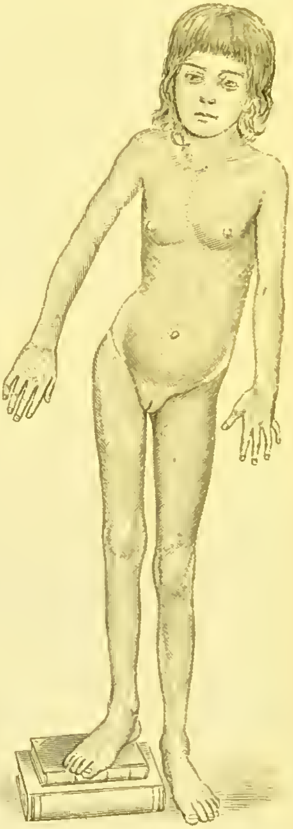

FIG. 226.—Advanced Tuberculous Disease of Right Hip-joint in a girl æt. 10. Adduction compensated for by tilting of pelvis.

When adduction is very pronounced, the patient is unable to restore the normal parallelism of the limbs, and the knee on the affected side may cross the sound limb (Fig. 225). There is a deep groove at the junction of the perineum and thigh, and the pelvis may be tilted to such an extent that the lower ribs touch the iliac crest, and there is also great prominence of the trochanter. In the slighter degree of adduction, which is more often met with, the toes of the affected limb rest on the dorsum of the sound foot, as in a traumatic dislocation onto the dorsum ilii.

As a result of the pressure of the carious articular surfaces against one another, the upper end of the femur is drawn gradually upwards and backwards within the socket. Examination will then reveal the existence of a variable amount of *actual shortening;* it will also be found that the trochanter is displaced above Nélaton's line, and that it is nearer the middle line of the body, while above and behind the trochanter there is a prominent hard swelling corresponding to the margin of the enlarged acetabulum.

At this stage there may be a combination of real and of apparent shortening amounting to several inches.

In cases of long standing, retardation of growth of all the bones of the limb adds to the shortening. Shortening from dislocation will be referred to later.

The most reasonable explanation of the attitudes assumed in hip disease is that given by König. If the patient walks without crutches, as he is usually able to do at an early stage of the disease, the attitude of abduction, eversion, and slight flexion enables him to save the limb to the utmost extent; on the other hand, if he uses a crutch, as he is obliged to do at a more advanced stage of the disease, he no longer uses the limb for support, but draws it upwards and inwards into the position of adduction, inversion, and greater flexion. Similarly, if he is confined to bed he lies on the sound side, and the affected limb sinks by gravity so as to lie over the normal one in the position of adduction, inversion, and flexion. König's explanation accords with the fact that in the exceptional cases which begin with adduction and inversion we have usually to deal with a more severe type of the disease associated with grave osseous lesions —precisely those cases in which the patient is compelled from the outset to lie up or to adopt the use of crutches. Similarly the transition from the abducted to the adducted position is usually associated with such an aggravation of the symptoms that the patient is no longer able to walk without assistance.

During the third stage the other signs and symptoms become more pronounced; the patient becomes pale and thin; he is usually unable to leave his bed; his sleep is disturbed by startings of the limb, and the rigidity of the joint and the wasting of the muscles are very marked. Elevation of the temperature is exceptional. It may rise slightly after examination of the limb, or after a railway journey, or from abscess formation. Marked elevation of the temperature, apart from septic complications, usually indicates the development of tubercle elsewhere, or of general tuberculosis.

Abscess Formation in Hip Disease.—The formation of abscess is not related to any particular stage. It may occur before there is any deformity, or it may be deferred until the disease has apparently recovered. Its site and direction of spread are influenced by its seat of origin and by the anatomical arrangement of the parts.

Abscesses which appear *in the thigh* usually originate in the cavity of the joint; less frequently they are peri-articular. They may point in front of or behind the joint.

The *anterior abscess* usually comes to the surface on one or other side of the psoas muscle. From the resistance offered by the fascia lata, the pus may gravitate down the thigh before perforating the fascia and pointing. In connection with these anterior abscesses, it occasionally happens that when they have opened and become septic the femoral vessels may be eroded, leading to serious, and it may be fatal hæmorrhage. The *posterior abscess* develops in the gluteal region, and may make its way to the surface through the gluteus maximus, more often it points at the lower border of this muscle in the region of the great trochanter, or it may gravitate down the thigh.

The abscesses which form *within the pelvis* originate either in connection with the acetabulum or in relation to the psoas muscle where it passes in front of the joint. Those which are directly connected with disease of the acetabulum may remain localised to the lateral wall of the pelvis, or may spread backwards towards the hollow of the sacrum. They may open into the bladder or rectum, or they may ascend into the iliac fossa and point above Poupart's ligament, or descend towards the ischio-rectal fossa. The abscess which develops in relation to the psoas muscle may be shaped like an hour-glass, one sac occupying the iliac fossa, the other filling up the adductor region of the thigh, the two sacs communicating with each other through a narrow neck beneath Poupart's ligament.

So long as the skin is unbroken the abscess is usually unattended with fever or pain. The clinical importance of abscess formation lies in the fact that if the abscess bursts externally septic infection is almost inevitable. This may result in abundant purulent discharge, or, where the external opening is insufficient for drainage, in repeated attacks of inflammation attended with fever, burrowing of pus, and the formation of fresh sinuses, until the condition of the patient merges into that of hectic fever or chronic septic poisoning. He loses ground from day to day, may become the subject of waxy disease in the viscera, or may die of exhaustion, tuberculous meningitis, or general tuberculosis. It is not to be inferred that the presence of septic sinuses is incompatible with recovery, but they are a source of danger to which the patient should never be exposed if he comes under treatment with unbroken skin.

Dislocation is a comparatively rare complication of hip disease; it is most likely to occur in untreated cases during the stage of adduction with inversion. It is known to have taken place during sleep, from the same spasmodic contractions of muscles that give rise to startings at night. In dorsal dislocation, which is the most common form, adduction and inversion are pronounced, the trochanter projects above and behind Nélaton's line, and the head of the bone may be felt on the dorsum ilii. When dislocation has occurred there may be less complaint of pain or of startings than before, and passive movements may be elicited which up till then were impossible.

Bilateral Hip Disease.—Both hip-joints may become affected with tuberculous disease, either simultaneously or successively, each running its course independently of the other. The patient is necessarily confined to the recumbent posture, and if the disease is recovered from, his capacity for walking may be seriously impaired, especially if cure has taken place with rigidity or ankylosis in both joints, and if the joints have become fixed in an undesirable attitude. Both the length and the attitude of the two limbs may be altered. The most striking deformity occurs when both limbs are adducted so that they cross each other,—the "scissor-leg" or "crossed-leg" deformity,—in which the patient, if able to walk at all, does so by forward movements from the knees.

Diagnosis of Hip Disease.—The diagnosis is to be made not only from other affections of the joint itself, but also from morbid conditions in the vicinity of the hip, since in any of these the patient may seek advice on account of pain and a limp in walking. The patient should be stripped, and if able to walk, his gait should be observed. He is then examined in the recumbent position, and attention is directed to the comparative length of the limbs, to the attitude of the limbs and pelvis, and to the movements at the hip-joint, especially those of rotation. When there is any doubt as to the diagnosis the examination should be repeated at intervals of a week or ten days. In children there are three non-febrile conditions attended with a limp and with shortening of the limb, which may be mistaken for hip disease—congenital dislocation, coxa vara, and infantile paralysis; but in all of these the normal movements are less restricted than in disease of the joint, and the history of onset is different.

In tuberculous disease of the sacro-iliac joint, the pelvis may be tilted, and the limb apparently lengthened on the affected side, but the movements at the hip are retained. In tuberculous disease of the great trochanter the resemblance to morbus coxæ is very close indeed. There may be abduction, eversion, impairment of mobility, and swelling in the region of the trochanter, followed by abscess formation. The movements are less restricted than in disease of the joint. The diagnosis, however, may not be completed until the swelling about the trochanter is explored by operation, and this should not be delayed, otherwise the disease may extend to the joint. The same remarks apply to disease of the bursæ over the great trochanter, especially of the bursa beneath the aponeurosis of the gluteus maximus.

In psoas abscess, or in disease of the bursa underneath the psoas, the limb is flexed and everted, there may be lordosis, and the patient may walk with a limp. The diagnosis is made by testing the movements at the hip—in commencing psoas abscess they are restricted or absent only in the direction opposed to the existing attitude; whereas in hip disease they are restricted or absent in all directions, especially abduction and rotation.

Appendicitis in children is sometimes associated with flexion of the hip, and may be mistaken for hip disease through omitting to test the movements of the joint.

Disease of the lymphatic glands in the groin also may cause flexion and a limp in walking.

Mild forms of staphylococcal osteomyelitis of the upper end of the femur may simulate hip disease; but these are more likely to be attended with fever, there is greater tenderness over the bone, the movements at the joint are less restricted, and there is more immediate improvement from rest in bed.

Sciatica has been mistaken for hip disease as a result of careless examination. In sciatica, flexion at the hip is only restricted when at the same time the leg is extended on the thigh.

New growths in the vicinity of the hip—especially commencing sarcoma of the upper end of the femur—may be very difficult to differentiate from hip disease. In sarcoma the movements at the joint are less restricted. Skiagrams may give definite information. The recognition of egg-shell crackling or of pulsation is only possible in the advanced stages of sarcoma, and is therefore of little value in diagnosis.

The diagnosis *from other diseases of the hip-joint* is difficult only in exceptional cases.

In traumatic effusion into the joint, the symptoms follow directly upon an injury, are more definite from the first, and rapidly improve under rest.

Pyogenic affections of the hip, resulting from staphylococcal osteomyelitis of the neck of the femur, from typhoid, or from gonorrhœa, may raise difficulties in diagnosis, especially when they are subacute and do not go the length of suppuration. There is usually, however, some pyrexia and greater tenderness, and pyogenic lesions may be present elsewhere in the body.

Charcot's disease and arthritis deformans usually occur under conditions which render any confusion with hip disease unlikely. In arthritis deformans there is less restriction of the movements at the joint, and these are accompanied by a sensation of roughness or crepitation.

In hysterical affections of the hip, while there may be the typical attitude and rigidity of tuberculous disease, it is usually possible, when the patient's attention is distracted, to elicit movement at the joint or to alter the attitude of the limb.

Prognosis.—The prognosis in hip disease is more serious than in tuberculosis of other joints, excepting only those of the spine. While recovery may take place at any stage and even in the most unlikely cases, it becomes less probable the longer the disease has been left untreated. In the initial stage recovery may be attended with a certain range of movement; but when the disease has advanced to the stage of destruction of the articular surfaces, the joint is liable to become ankylosed, and its usefulness will depend upon the attitude of the limb and the degree of shortening. The average shortening amounts to from one and a half to two inches, but it may attain to as much as six inches. The formation of abscess, especially within the pelvis, is a serious complication. The prognosis is most unfavourable where there are gross lesions of the bones, and infected sinuses, especially in adults who are the subjects of tuberculosis elsewhere. Statistics show that formerly the mortality from hip disease varied from ten per cent in cases of dry arthritis, to forty per cent in cases with abscess; but the risks from abscess have been much reduced in recent years.

Death usually results from meningeal, pulmonary, or general tuberculosis, septic complications, and waxy degeneration. In cases which terminate fatally the average duration of the disease is from one and a half to three years. In cases which recover the duration varies indefinitely. Where there are bone lesions and septic sinuses, the disease, which may have begun in childhood, may still be present after the age of twenty. It is a safe rule in practice to assume that even mild cases rarely recover in less than two years. The patient or his relatives should be informed of this, and also that they are not to expect recovery without some impairment of function, and that complications may arise necessitating more prolonged treatment or operative interference. They should also be informed of the tendency of the disease to relapse.

Treatment.—A large proportion of cases recover under conservative treatment, and the functional results are so much better than those following operative interference, that unless there are special indications to the contrary conservative measures should always be adopted.

Conservative Treatment.—This consists in protecting the limb from injurious strain or pressure, and in preventing deformity. Absolute rest is imperative, and the patient must be confined to bed until pain and tenderness have disappeared and sleep is undisturbed.

Extension by means of the weight and pulley is of most service in cases attended with pain, spasmodic contraction of muscles, rigidity of the joint, or a deformed attitude of the limb. The weight employed varies from three to eight pounds in children, to ten or more pounds in adolescents and adults, and must be adjusted to meet the requirements of each case. If pain returns after having been relieved, it is due to overstretching of the ligaments, and the weight should be diminished or removed for a time. If there is deformity, the line of traction should at first be in the axis of the deformed limb, and should later be gradually brought into the normal axis of the limb. Flexion yields most readily. If there is abduction, extension should be applied to both limbs, and if there is adduction it may be necessary to apply counter-extension by means of a perineal band. The attitude ultimately desired is one of almost complete extension with slight abduction.

When there is a *deformed attitude which does not readily yield to extension*, as, for example, in cases which do not come under treatment until the deformity has existed for some time, there is considerable advantage in correcting it at once. Under anæsthesia this is readily accomplished in the majority of cases by manipulation; but if the tendons and fasciæ are so contracted that this is impossible they should be divided.

To ensure absolute rest in the attitude of extension and slight abduction, additional means may be necessary in restless children: a long splint may be applied on the sound side, and a heavy sand-bag on the affected side; or, better still, a double long splint and cross-bar. The long splint on the affected side is made with a hinge opposite the hip-joint, to permit of varying the degree of abduction. If there is any tendency to rotation, it may be prevented by strips of strong adhesive plaster, wrapped round the thigh in a direction opposed to that of the rotation, and fixed to the long splint or sand-bag.

Ambulant Treatment.—Treatment by extension and the long splint should be continued until pain, tenderness, and muscular contraction have disappeared, and the limb has been brought into the attitude of slight abduction. The joint must be kept at rest, and the affected limb is not allowed to touch the ground. In children who are unable to use crutches, a double Thomas' splint, a Phelp's box, a Bonnet's wire cuirass, or plaster of Paris is employed. By using any of these appliances the child is converted into a rigid object, capable of being carried about from one room to another or into the open air. Personally, we have obtained the best results from the double Thomas' splint, like that used for spinal disease, which extends from the occiput to the feet.

When the patient is able to use crutches, the affected limb is prevented from touching the ground by fixing a patten to the sole of the boot on the sound side. The hip-joint is kept rigid in the abducted position by a Thomas' or a Taylor's splint, or by a case of plaster of Paris. The plaster is used chiefly in hospital out-patients who cannot be kept under continual supervision. It may be strengthened by broad strips of aluminium, and should be renewed at intervals of from six weeks to three months. The treatment is continued for some time after all symptoms have disappeared. The duration of treatment varies from six months to two years. If at any time there is a return of active symptoms, the patient must again lie up with extension applied to the limb.

Counter-irritation by means of the actual cautery may give considerable relief where there is much pain in the persistent hip disease of adults. It is applied over the great trochanter.

Treatment of Abscess.—The early recognition and prompt treatment of abscess before it has spread widely or is threatening to rupture externally, has greatly reduced the suffering and mortality from hip disease. The methods of treatment are the same as are employed in other joints. If an open operation is adopted, the opportunity may be taken of clearing out any extra-articular bone lesion at the same time.

Operative interference is indicated—1. When the disease is progressing rapidly, or when it advances in spite of conservative treatment. 2. When the disease relapses after apparent cure, and is attended with suppuration. 3. When, along with evidence of persistence of the disease, there is a deformed attitude which does not yield to extension or correction under anæsthesia, or where there is dislocation of the head of the femur, or separation of its upper epiphysis. 4. When there is an abscess within the pelvis, or other evidence of disease of the acetabulum. 5. When there are septic sinuses and persistent discharge with symptoms of hectic and of waxy degeneration. These last are most unfavourable cases whether an operation is performed or not; at the same time, operation, if it is not too long delayed, may afford the only chance of recovery. 6. In adults who show no signs of recovery within a year from the onset of the disease. This indication specially refers to "bread-winners," in whom it is specially urgent that they should be able to resume work. In children there is no urgency for resuming active life, the prospects of spontaneous recovery are considerable, and an operation may interfere with the subsequent growth of the limb.

Nature of the Operative Interference.—As operation must often be undertaken without an accurate knowledge of the exact condition of matters within and around the joint, we are frequently unable to decide beforehand the extent of the operation which is required. Our object should be to expose the disease wherever situated, and to remove it with the least possible damage to the normal structures. The more open the method of operation the better, since more reliable information is obtained by inspection than by palpation. These indications are best fulfilled by the operation devised by Kocher, which, by permitting of dislocation of the femur, affords free access to all parts of the joint. Tuberculous synovial membrane is removed in the usual way. If it should be found that the disease in the head of the bone is limited to the surface or to isolated areas, it may be got rid of with the spoon or gouge, thus preserving the head, which is returned into the acetabulum at the close of the operation. This procedure, which may be described as an *arthrectomy*, should be practised wherever possible. If, on the other hand, there is a gross lesion in the head or neck of the bone, the neck is divided with a wire saw or chisel, and the head is removed. The remaining disease having been got rid of, the raw surface of the neck is implanted in the socket, or is made to lie opposite to it. This operation is described as an *excision* of the joint.

After either of these operations the limb is fixed in an attitude of marked abduction, so that when the patient resumes the erect posture he will be obliged to depress the pelvis on the affected side, in order to restore the parallelism of the limbs, and so to compensate, in part at any rate, for the shortening caused by the operation.

Amputation for tuberculous disease of the hip has become one of the rarest operations of surgery. It may still be required in cases which have continued to progress after excision, where there is disease of the pelvis or of the shaft of the femur, with septic sinuses, albuminuria, and hectic fever. In such cases the surgeon must be prepared not only to disarticulate at the hip-joint, but also to remove a portion of, or the entire innominate bone. Such extensive operations are usually carried out by some form of racket incision, which permits of the ligature of the main vessels as a preliminary measure. They are, however, very seldom justifiable.

The Correction of Deformity resulting from Antecedent Disease of the Hip.—The deformities concerned have been already described as accompaniments of hip disease. From neglect or from improper treatment they may have been allowed to persist, while the joint disease has recovered. They are associated either with ankylosis of the joint, or contracture of the soft parts, or with a combination of these conditions. The contracture of the soft parts specially involves the tendons, fasciæ, and ligaments on the anterior and inner aspects of the joint, and is usually present to such a degree that even if the joint were rendered mobile these shortened structures would prevent correction of the deformity. It should be borne in mind that the difficulties of correction are so considerable that it should not be attempted unless the deformity is a serious hindrance to locomotion or a bar to remunerative occupation. The deformity most often present consists in a combination of shortening, flexion, and adduction.

If flexion is the prominent feature it may be corrected by performing an osteotomy through the neck of the femur (Adam's operation), or through the trochanter if the neck of the bone has disappeared. The contracted soft parts are divided, either by subcutaneous or by open tenotomy; after which the limb is extended and abducted. In a patient whose occupation entails the sitting posture it may not be advisable to correct flexion:

If adduction and inversion are the prominent features the choice lies between a transverse osteotomy below the lesser trochanter (Gant's operation), an oblique osteotomy through the great trochanter (from above downwards and inwards), or a resection of the joint according to the special features of the case. The adductor muscles, fascia lata, and other contracted soft parts are divided by subcutaneous or open tenotomy. The limb is then forcibly abducted and extended, and maintained in this position by extension with the weight and pulley, and by the double long splint already described. In cases where the deformity is bilateral special efforts should be made to obtain a movable joint, at least on one side.

Pyogenic Diseases.—This group includes a number of conditions resulting from infection of the joint with the common pyogenic organisms, or with the gonococcus, or typhoid bacillus. While the organisms usually gain access to the tissues of the joint through the blood-stream, a direct infection is occasionally observed from suppuration in the femoral lymphatic glands or in the bursa under the ilio-psoas. The pyogenic diseases are chiefly met with in childhood and youth.

The *clinical features* vary with the gravity of the infection; they are sometimes much less striking than might be expected, and are remarkably latent when the hip affection occurs as a complication of some general illness such as scarlet fever. The hip affection has sometimes been entirely overlooked during its active stage, and only at a later period has the head of the femur been found lying on the dorsum ilii, or the joint found to be ankylosed. In the acute arthritis of infants which results also from staphylococcal osteomyelitis of the femur or acetabulum, the clinical features may be comparatively mild, but as a rule they assume a type in which the suppurative element predominates. The limb usually becomes flexed and adducted, and a swelling forms in front of the joint at the upper part of Scarpa's triangle. The head of the bone may be dislocated or the upper femoral epiphysis detached. The gonorrhœal affections resemble those in other joints.

The occurrence of pathological dislocation has been specially observed in relation to typhoid and other fevers, usually from some slight movement or push, the limb being flexed and adducted. If the child has recovered with dislocation on to the dorsum ilii, he is usually able to walk and run about, but with a limp which becomes more pronounced as he grows up. The clinical features closely resemble those of congenital dislocation, and it may be impossible to distinguish between them unless an accurate history is obtainable.

Treatment.—The limb is extended by means of the weight and pulley, and kept at rest with the single or double long splint, or by means of sandbags. If there is evidence of suppuration the joint should be explored by an anterior incision inclining downwards and inwards from the anterior superior iliac spine; a posterior opening may be made for drainage. In children it is remarkable how completely the joint may recover if the pus is promptly evacuated.

If there is dislocation of the femur, it should be reduced by manipulation with or without preliminary extension; it has been successful in about one-half of the cases in which it has been attempted. Preliminary tenotomy of the shortened tendons may be required in some cases. Where reduction by manipulation is impossible, the joint structures should be exposed by one or other of the methods employed in excising the joint, and the head of the bone, if present, is replaced in the acetabulum; in the absence of the head, the neck should be fixed against the socket, thereby diminishing shortening at the expense of mobility.

Chronic Rheumatism.—The clinical features of chronic rheumatism of the hip are similar to those observed in other joints. Progressive stiffness and deformity, associated with contracture of the soft parts and fibrous ankylosis of the joint, are the outstanding features. The patient often becomes a helpless cripple.

Arthritis Deformans.—This disease is comparatively common at the hip, either as a monarticular affection or simultaneously with disease of other joints.

The changes in the joint are characteristic of the dry form of the disease, and affect chiefly the cartilages and bones; the synovial changes which are so prominent in the knee are here of little importance. The atrophy and wearing away of the articular surfaces are accompanied by a new formation of cartilage and bone around their margins. The head of the femur may acquire the shape of a helmet, or mushroom, or limpet shell. From absorption taking place in the neck of the femur, the head may come to be sessile at the base of the neck, and may occupy a level considerably below that of the great trochanter (Fig. 227). These changes may extend to the upper part of the shaft of the femur, and result in curving of the shaft and neck, suggesting a resemblance to a point of interrogation. The acetabulum may "wander" backwards and upwards, as in tuberculous disease, It is usually deepened, and its floor may project on the pelvic aspect; its margins may form a projecting collar which overhangs the neck of the femur, or grasps it so that even in the macerated condition the head is imprisoned in the socket and the joint locked. There is eburnation of the articular surfaces similar to that seen in other joints.

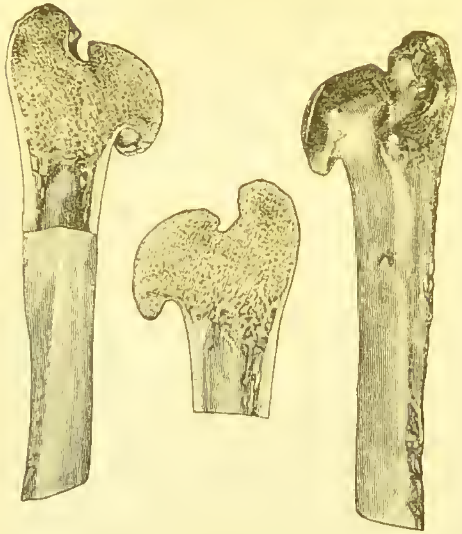

FIG. 227.—The Upper End of the Femur in advanced Arthritis Deformans of Hip, showing absorption of neck and downward displacement of head of bone.

(Museum of Royal College of Surgeons, Edinburgh.)

These changes are necessarily associated with great restriction of the movements of the joint, and with striking deformity, which consists in shortening of the limb, usually with eversion—sometimes with flexion and adduction. The trochanter is nearly always displaced upwards and backwards in relation to Nélaton's line.

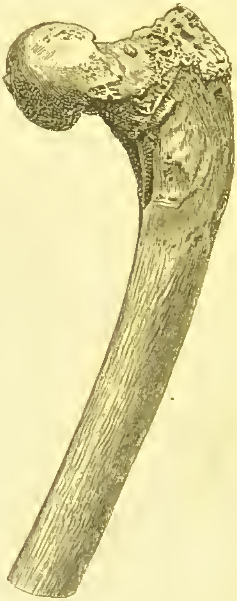

FIG. 228.—The Upper End of the Femur in advanced Arthritis Deformans of Hip. The shaft is curved, and the head of the bone is at a lower level than the great trochanter.

(Anatomical Museum, University of Edinburgh.)

The *clinical features* are usually so characteristic that there is little difficulty in diagnosis. Restriction of the movements of abduction and adduction, the presence of cracking and of grating of the articular surfaces, and the aggravation of the pain and stiffness after resting the limb, are helpful in recognising arthritis deformans. The prominence of sciatic pain from the nerve being involved as it passes over the joint may lead to the disease being regarded as sciatica.

The greatest difficulty is met with in cases where the disease occurs in early life as a monarticular affection, for the resemblance to tuberculosis may be so close that the diagnosis is impossible until the joint is explored by operation. Skiagrams do not always aid in differentiating between them.

The *treatment* consists in seeking to preserve the normal movements of the joint, and in diminishing the pressure on the articular surfaces by the use of sticks or crutches in walking. Shortening of the limb may be compensated for by heightening the sole of the boot. Forcible movements of the joint under an anæsthetic do more harm than good. Excision of the joint has in some cases yielded satisfactory results; it is indicated in young patients who are otherwise healthy, and who are unable to walk on account of pain and deformity. The treatment of arthritis deformans in general must also be carried out.

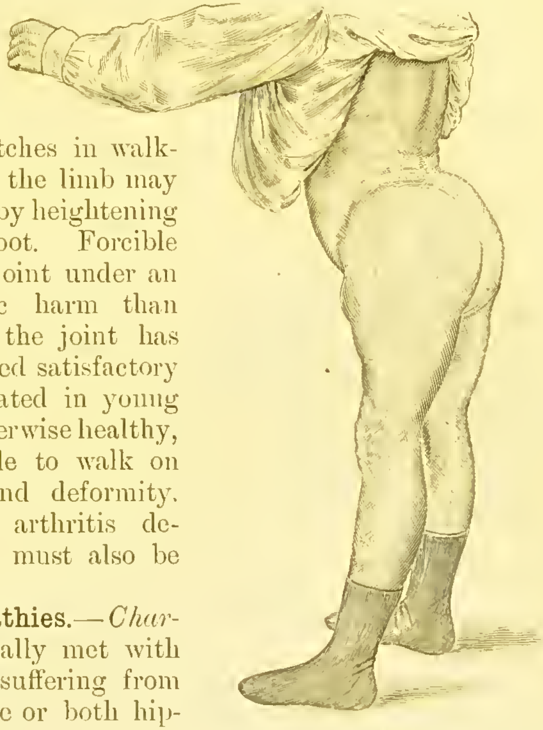

FIG. 229. — Bilateral Charcot's Disease of Hip, with dislocation of head of femur on to dorsum ilii.

(Dr. H. G. Langwill's case.)

Neuro-Arthropathies.—*Charcot's disease* is usually met with in men over thirty suffering from tabes dorsalis. One or both hip-joints may be affected. Sometimes the development of a fluctuating swelling in the upper part of Scarpa's triangle may indicate the presence of hydrops. In many of the recorded cases, however, attention has been first directed to the disease by the deformity and limp associated with disappearance of the head of the femur, or by the occurrence of pathological dislocation. The absence of pain and tenderness is characteristic. When dislocation has occurred, the limb is short, and the upper end of the femur is freely movable on the dorsum ilii. When both hips are dislocated (Fig. 229) the attitude and gait are similar to those observed in bilateral congenital dislocation. The rotation arc of the great trochanter may be much reduced as a result of the disappearance of the head of the femur. There may be considerable formation of new bone, giving rise to large tumour-like masses in relation to the capsular ligament and the muscles surrounding the joint.

The *treatment* consists in protecting and supporting the joint. When the affection is unilateral, advantage may be derived from a Thomas' or other form of splint, along with a patten and crutches; in bilateral cases, from the use of crutches alone.

Hysterical affections of the hip resemble those met with in other joints.

The Knee-Joint.

The knee is more often the seat of disease than any other joint in the body.

The synovial membrane of the knee extends beneath the quadriceps extensor as a cul-de-sac, which either communicates with the subcrural bursa, or with it forms one continuous cavity (Fig. 232). When the joint is distended with fluid this upper pouch bulges above and on either side of the patella, and this bone is "floated" off the condyles of the femur. When there is only a small amount of fluid in the knee it is most easily recognised while the patient stands with his feet together and the trunk bent forwards at the hip-joints. The complete relaxation of the quadriceps allows the fluid to bulge above and on each side of the patella, where its presence is readily detected, especially on comparison with the joint of the other side.

On account of the great extent of the synovial membrane, serous effusion may accumulate in the joint with great rapidity, as a result either of injury or disease. The villous processes and fringes may take on an exaggerated growth, and give rise to pedunculated and other forms of loose body.

The bursæ in the popliteal space, and especially that between the semi-membranosus and the inner head of the gastrocnemius, as well as the subcrural bursa, frequently communicate with the synovial cavity of the knee.

The epiphyses at the knee are chiefly responsible for the growth in length of the lower extremity, and are late in uniting with their respective shafts. Serious shortening of the limb, therefore, may result if their functions are interfered with by disease or injury. The epiphysial cartilages lie beyond the limits of the synovial cavity, so that infective lesions at the ossifying junctions are less likely to spread to the joint than is the case at the hip or shoulder, where the epiphyses lie partly or wholly within the joint.

Deformed Attitudes in Knee-joint Disease.—The attitude most often assumed is that of flexion, with or without external rotation of the leg and foot. The occurrence of flexion is explained by its being the resting attitude of the joint, and that which affords most ease and comfort to the patient. Once the joint is flexed, the involuntary contraction of the flexor muscles maintains the attitude, and if the patient is able to use the limb in walking, the weight of the body is a powerful factor in increasing it. The external rotation of the leg is probably associated with contraction of the biceps muscle. Backward displacement of the tibia is chiefly met with in neglected cases of chronic disease of the knee when the patient has walked on the limb after it has become flexed.

In certain cases genu valgum or abduction of the leg may be present along with a slight degree of flexion. The valgus attitude is associated with slight outward displacement of the patella, with prominence and apparent enlargement of the internal condyle, with depression of the pelvis on the diseased side and apparent lengthening of the limb.

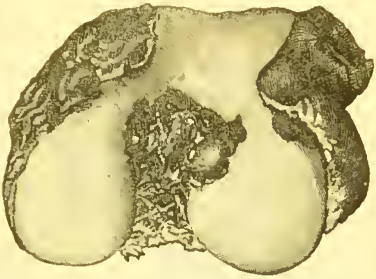

Fig. 230.—Tuberculous Synovial Membrane of Knee, spreading over articular surface of femur.

All these deformities are met with in their most typical forms in tuberculous disease of the knee in young subjects.

Tuberculous Disease.—While especially common in childhood and youth, tuberculous disease of the knee may occur at any period of life, and is not uncommon in patients over fifty. The frequency with which the disease originates in the synovial membrane and in the bones respectively would appear to be about equal.

When the synovial membrane is diseased, it tends to grow inwards over the articular surfaces. In the case of the femur this usually takes place from the lateral margins of the condyles at the level of the lower edge of the patella, often shutting off the supra-patellar pouch and fixing the knee-cap to the femur (Fig. 230). In the tibia and patella the synovial membrane grows in from the margins, diminishing the area of their articular surfaces.

The ingrowth of synovial membrane may fill up the entire cavity of the joint, or may divide it up into compartments, one usually being above the patella, and two below, in relation to the condyles of the femur. When, under these conditions, a tuberculous focus in the bone erupts into the joint, the infection may be confined to one or other of these compartments. The destructive changes of the articular surfaces are similar to those in other joints. That form of the disease known as white swelling is due not only to tuberculous thickening of the synovial membrane, but in addition to thickening and gelatinous transformation of the para-synovial connective tissue, and especially of the fat around the joint. The nature and seat of the bone lesions are subject to the same wide variations as in other joints; the tibia and femur are affected with about equal frequency. Multiple small foci may be found beneath the articular cartilage of the tibia, or along the lateral margins of the femoral condyles—especially the internal. Caseating foci are comparatively rare, but sometimes attain a considerable size—especially in the head of the tibia, where they may assume the character of a caseous abscess. Sclerosed foci, which may form sequestra, are comparatively common (Fig. 231). Diffuse caseating osteomyelitis may involve an entire epiphysis and extend into the adjacent shaft. The more severe bone lesions in young children frequently erupt outside the joint, either into the popliteal space or on one of the lateral aspects of the limb.

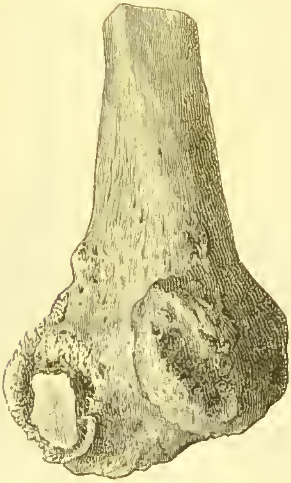

FIG. 231.—The Lower End of Femur from an advanced case of Tuberculous Arthritis of the Knee. Towards the posterior aspect of the internal condyle there is a wedge-shaped sequestrum, of which the surface exposed to the joint is polished like porcelain.

(Anatomical Museum, University of Edinburgh.)

Clinical Types of Tuberculous Disease of the Knee.—Hydrops tuberculosis is that type in which the outstanding feature is the accumulation of fluid in the joint. It usually arises from a purely synovial lesion, but where the joint suddenly becomes distended with fluid it may depend on foci in the bones.

Hydrops is chiefly met with in young adults. As a rule, the fluid accumulates gradually and imperceptibly, stretching the capsule, and pushing the patella forwards, so that it floats. There is little pain or interference with the functions of the joint; the patient is usually able to walk, but is easily tired. The amount of fluid diminishes under rest, and increases after use of the joint. In a certain number of cases it may be possible to recognise some thickening of the synovial membrane, or the presence of friction or crepitation from the mutual contact of floating masses of fibrin or melon-seed bodies. This is best appreciated if the knee is alternately flexed and extended by the patient while the surgeon grasps and compresses it with both his hands. If the joint is opened, fibrinous material, often in the form of melon-seed bodies, may be found lining the synovial membrane and partially covering the articular surfaces. These may be found in the fluid withdrawn from the joint by tapping.

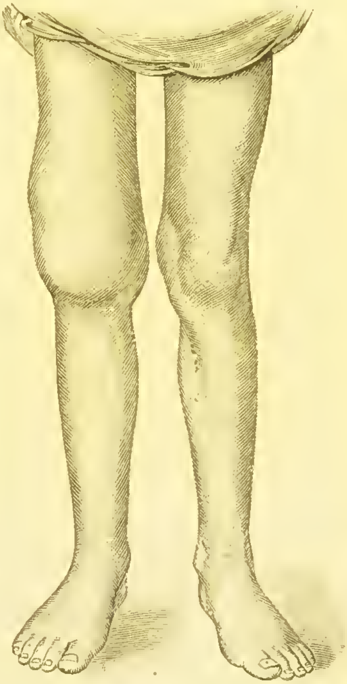

FIG. 232.—Tuberculous Hydrops of Knee with distension of subcrural bursa.

Tuberculous hydrops is to be diagnosed from the effusion which results from sprain, from the hydrops of gonorrhœa, arthritis deformans, Charcot's disease, and pyogenic disease in an adjacent bone, and from the hæmarthrosis met with in bleeders. Given a patient, and especially a young adult with fluid in the knee, and having excluded injury, it is most likely due either to tuberculosis or gonorrhœa. The presence of melon-seed bodies is confirmatory of the diagnosis of tubercle.

Tuberculous hydrops is especially amenable to conservative treatment by rest and by injections of iodoform. Relapse, however, is not uncommon, and experience shows that if the disease is neglected there may be a gradual transition from an innocent hydrops into the graver types of synovial tuberculosis.

Papillary or Nodular Tubercle of the Synovial Membrane.—This may be employed as a clinical term to distinguish a condition in which there is a fringy, papillary, or polypoidal growth from the synovial membrane. It is most often met with in adult males between the ages of twenty and forty. The onset and progress are gradual, the chief complaint being of stiffness and swelling, which are worse after exertion. Sometimes there are symptoms of loose body, such as occasional locking of the joint with pain, and inability to extend the limb; but the locking is easily disengaged, and the movements are free again. The patient may give a history of several years' partial and intermittent disability, with lameness and occasional locking, although he may have been able to go about or even to continue his occupation.

The joint exhibits a moderate degree of hydrops. When this has subsided under rest it may be possible to feel ill-defined cords, or tufts or nodular masses, and to grasp between the fingers those in the supra-patellar pouch. There is little wasting of muscles, and it is quite exceptional to observe any symptoms of implication of the articular surfaces or the formation of a cold abscess.

On opening the joint there may escape fluid and loose bodies similar to those described under hydrops, and if the finger is introduced into the cavity the upper pouch may be felt to be occupied by fringes or polypoidal processes derived from the synovial membrane.

The diagnosis is to be made from arthritis deformans, and in some cases from loose body of other than tuberculous origin.

The treatment specially applicable to this type of tuberculous disease is to perform a partial arthrectomy, removing the affected synovial membrane.

Cold abscess or empyema of the knee is a rare condition in which the joint becomes filled with pus. It usually results from a primary tuberculosis of the synovial membrane in those who are much reduced in health, and who are the subjects of tuberculosis elsewhere. While usually insidious in its development and progress, an acute form attended with fever may be met with in children. The treatment consists in evacuating the pus, and in filling the joint with iodoform glycerin. In the absence of decided improvement, however, recourse must be had to arthrectomy.

Diffuse Thickening of the Synovial Membrane—White Swelling.—When this type of disease originates in the synovial membrane and remains confined to it, the chief clinical feature is that of an indolent elastic swelling in the area of the joint. The swelling tapers off above and below, so that it acquires a fusiform shape, and it appears greater than it really is on account of wasting of the muscles. There is little impairment of movement. The patient limps slightly, keeps the knee slightly flexed, and complains of tiredness and stiffness after exertion.

As time goes on the disease tends to invade and destroy the articular surfaces, and gives rise to more severe symptoms. There is pain, which is readily excited by jarring of the limb or by any attempt at movement. There may be startings at night and interference with sleep. The joint is held rigid. If untreated, flexion becomes more pronounced,—it may be to a right angle,—the leg and foot are rotated outwards, and in children the tibia may be displaced backwards. The wasting of muscles continues, the part becomes hot to the touch, the swelling increases, and may show areas of softening or fluctuation from abscess formation.

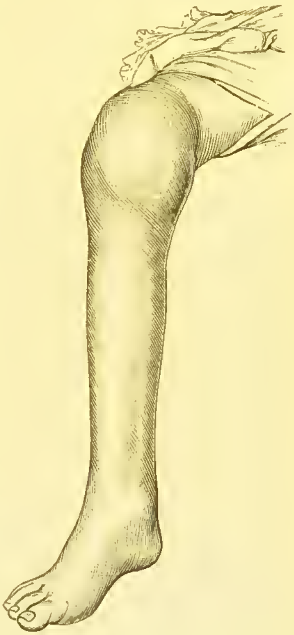

FIG. 233.—Diffuse Thickening of Synovial Membrane of Knee (White Swelling).

White swelling is to be differentiated from peri-synovial gummata, from sarcoma of the lower end of the femur, and from bleeder's knee. In the first of these the swelling is nodular and less uniform, and there may be tertiary ulcers or depressed scars in the neighbourhood of the patella. In sarcoma the swelling is more marked on one or other side of the joint, it is uneven or nodular, it does not correspond to the shape of the synovial membrane, but may extend beyond the limits of the joint, and it involves the bone to a greater extent than is usual in cases of joint disease. Skiagrams may show expansion of the bone in central tumours, or abundant new bone in cases of ossifying sarcoma. In difficult cases recourse should be had to exploratory incision. The diagnosis of bleeder's knee is chiefly to be made from the history.

Primary Tuberculous Disease in the Bones of the Knee.—So long as the foci are confined to the interior of the bone affected it is usually impossible to recognise their existence, unless they are of sufficient size to cause enlargement of the bone or to be recognisable in a skiagram.

If the focus reaches the surface of the bone outside the limits of the synovial membrane there is tenderness on pressure, pain in walking, and probably a limp, and a cold abscess may develop. The joint, although perhaps a little sensitive and restricted in its movements, and in some cases the seat of a serous effusion, may not become infected with tubercle unless the disease in the bone is neglected.

If the focus reaches the surface of the bone at the level of the reflection of the synovial membrane, the membrane becomes thickened at the site of infection in the first instance; but as time goes on, it becomes infected throughout, just as in primary synovial disease. The clinical features are similar to those described under the head of diffuse thickening of the synovial membrane,—only they are apt to be more severe and to progress more rapidly, and to be associated with abscess formation in the vicinity of the osseous focus.

If the focus reaches the surface of the bone where it is covered by articular cartilage, the latter is perforated or detached, and the joint becomes infected. The symptoms vary with the nature of the perforation and the amount of infective material thrown into the joint. The resulting joint disease may evolve gradually and assume the characters of a dry arthritis with pain, rigidity and tendency towards fibrous ankylosis, or it may develop suddenly and progress rapidly towards suppuration and disorganisation of the joint.

Tuberculous disease, attended only by symptoms of involvement of the articular surfaces, is to be differentiated from arthritis deformans and from hysterical knee.

The formation of abscess in tuberculous disease of the knee takes place in rather more than fifty per cent. of cases. Abscesses may originate in the substance of the synovial membrane, within the synovial cavity or in one of its compartments, in the surrounding cellular tissue, or in relation to one of the bursæ in the popliteal space. When left to themselves such abscesses tend to spread up into the thigh or down the back of the leg, and numerous sinuses may result from their rupture through the skin.

The diagnosis of tuberculous disease of the knee has been considered in relation to the different clinical types.

Treatment.—Conservative measures are indicated where there is a prospect of obtaining a movable joint. When the articular surfaces are so involved that this is no longer possible, it is usually both a waste of time and a source of danger to the patient to persist with conservative measures. By means of operation one may anticipate cure of the disease within a definite time, and although the knee is stiff the limb is a useful one. We may be justified in persevering a little longer with conservative methods in the case of children, because they have greater recuperative powers, because time is of secondary importance, and because extensive operations on the bones may interfere with the growth of the limb.

The methods of *conservative treatment* are similar to those employed in other joints. The limb is immobilised in the position of almost complete extension. If the joint is sensitive and tends to be flexed, the patient is confined to bed, the limb is secured to a posterior splint, and extension with the weight and pulley is applied to the leg. If there is no pain or tendency to flexion, or when these have been overcome, the limb is put up in a Thomas' splint, and the patient is allowed to go about. The splint is removed at intervals to allow of examination of the joint, for washing and douching of the limb, and at a later period for movement, massage, and electrical stimulation of the atrophied muscles. The splint is worn for a period varying from six to twelve months; before being discarded altogether it may be left off at night; it is ultimately replaced by an elastic bandage.

Treatment by venous congestion and the injection of iodoform glycerin may in some cases be advantageously added to that by rest. The needle of the syringe is introduced either into the upper pouch or into the interval between the bones on the inner side of the ligamentum patellæ.

The treatment of abscess and of extra-articular foci in the bones is carried out on the same lines as in other joints.

The indications for *operative treatment* may be stated as follows:—1. Where there are marked symptoms of destruction of the articular cartilages. 2. Where there is a deformed attitude incapable of being rectified without operation. 3. Where the general health requires that the disease should be got rid of by the most rapid method. 4. Where the disease has progressed in spite of conservative treatment, or where, from the mere persistence of the disease, there is reason to suspect the existence of serious disease in the bones, or, finally, where the disease has relapsed after apparent cure.

In patients under fifteen years of age the operation of arthrectomy is preferred. It consists in removing the tuberculous synovial membrane, and, if the articular surfaces are affected, paring them with a strong knife. Above the age of fifteen the joint is excised; the ends of the bones are removed with the saw, and diseased soft structures with the knife or scissors.

Amputation is performed irrespective of age when arthrectomy or excision is incapable of removing the whole of the disease, and this is called for because of the general health.

Treatment of Deformities resulting from Antecedent Disease of the Knee.—When the articular surfaces are fairly preserved, and the flexion is due to contraction of the posterior part of the capsule and other structures in the popliteal space, these should be divided through an oblique incision made from above downwards across the space. If forcible correction is attempted without cutting, it must be carried out gradually. When there is fibrous or osseous ankylosis in the flexed position and no hope of a movable joint, a more extensive operation is necessary. In adults this consists in removing a wedge of bone. In patients who are still growing, it may be possible to straighten the limb by a modified arthrectomy and the removal of a thin slice of bone, or by dividing the femur above the joint. The alternative is to wait until the patient is nearly fully grown, and then remove a wedge of bone.

Pyogenic diseases may result from infection through the blood-stream, from the spread of infection from one of the adjacent bones, or from a penetrating wound of the joint. The clinical features, while varying in acuteness and severity, always include well-marked local signs, effusion into the synovial cavity being a prominent and easily recognised feature. The commoner types include the serous synovitis associated with disease in the adjacent bone, acute arthritis of infants, joint suppuration in pyæmia, septic arthritis following upon penetrating wounds, and the affections which result from gonorrhœa.

The *treatment* is directed to meet the features of each individual case. The limb is immobilised on a posterior splint. If it is proposed to tap the joint, the trocar and cannula should be introduced obliquely into the supra-patellar pouch. If it is necessary to open and drain the joint, the incision is made on one or both sides of the patella. Even then the infection may continue to progress and threaten the life of the patient. Under these conditions the best procedure is to lay the joint freely open from side to side by dividing the patellar ligament and capsule; the limb is flexed, the whole wound left open and packed with gauze. As the infection subsides, the limb is gradually straightened. It is sometimes necessary to make additional incisions over the back of the condyles to drain the large synovial pouches which lie behind the crucial ligaments. If these methods fail, amputation through the thigh is to be had recourse to.

Arthritis deformans may affect the knee alone or in combination with other joints. The changes related to the synovial membrane attain their maximum development in this joint, and may assume the form of hydrops with or without fibrinous bodies, or of overgrowth of the synovial fringes and the formation of pedunculated loose bodies. Fibrillation of the cartilage imparts a feeling of roughness when the joint is grasped during flexion and extension, while lipping of the margins of the trochlear surface of the femur may be felt when the joint is fully flexed. When a portion of the "lipping" is broken off it may give rise to the symptoms of loose body. In advanced cases of hydrops with destruction of the cartilages, there may be lateral movement with grating of the articular surfaces.

In cases of hydrops the joint may be tapped and iodoform glycerin injected. When the symptoms are due to the presence of hypertrophied fringes and loose bodies, these may be removed by operation. When the disease is of an aggravated type and is confined to one knee, the question of excising the joint should be considered.

Bleeder's knee, *Charcot's disease*, *hysterical knee* and *loose bodies* in the joint have been sufficiently described in the general article on diseases of joints.

The Ankle-Joint.

There is a common synovial cavity for the ankle and the inferior tibio-fibular joints. The lower ossifying junction of the fibula is included within the limits of this synovial cavity; that of the tibia abuts on the surface immediately above the reflection of the synovial membrane. The astragalus is related to three articulations—the ankle above, the astragalo-scaphoid joint in front, and the calcaneo-astragaloid joint below. The close proximity of the different tendon sheaths to the ankle exposes them to the spread of infective disease from the joint; this is especially true of the sheaths of the peronei and of the tibialis posticus.

Tuberculous Disease.—Tuberculous disease at the ankle is as frequently met with in adolescents and adults as it is in children. In the majority of cases it commences in the synovial membrane. Gross lesions in the bones are comparatively rare, and are more often met with in the head and neck of the astragalus than in the lower ends of the tibia and fibula.

Primary synovial disease usually exhibits the features of white swelling, anteriorly projecting beneath the extensor tendons, and posteriorly filling up the hollows on either side of the tendo Achillis. At a later stage the swelling is also seen below the malleoli (Fig. 234). The foot may retain its normal attitude, or the toes may be slightly pointed and adducted. The calf muscles are wasted, there is little complaint of pain, and the movements of the joint may be so little interfered with that the patient can walk without limping.

When the articular surfaces have become affected, there is the usual pain and sensitiveness, the normal movements are restricted or abolished, and the patient is unable to put the heel to the ground.

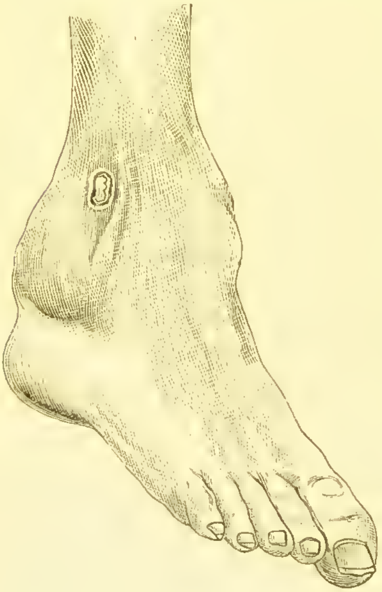

Fig. 234.—Advanced Tuberculous Disease of Synovial Membrane of Ankle.

Primary disease in the bones, in the absence of white swelling, may cause enlargement of one or other malleolus, localised pain and tenderness, and a limp in walking. In other cases the first signs may be the formation of abscess or the rapid development of articular symptoms. In such cases skiagrams may afford valuable information.

A combination of synovial and osseous disease is usually met with in advanced cases, the infection tending to spread diffusely throughout the whole region. Abscess formation is an early and prominent feature of disease of the ankle, whether of osseous or synovial origin, and sinuses are liable to form around the joint. Outlying abscesses and sinuses are usually the result of infection of the tendon sheaths in the neighbourhood. When tuberculous teno-synovitis occurs independently of disease of the ankle, the swelling is confined to one aspect of the joint. In sarcoma the swelling lacks the typical distribution of that met with in joint disease.

The prognosis is usually unfavourable in adults because of the extent of the disease and of the frequency of tuberculosis elsewhere in the body.

The *treatment* is conducted on the same lines as in other joints of the lower extremity. The foot is immobilised at a right angle to the leg by splints or plaster of Paris. If it is proposed to inject iodoform emulsion, the point of the needle is inserted below either malleolus, and is then pushed upwards along the astragalus. Abscess is treated on the usual lines. If localised disease in one of the bones is recognised before the joint is infected it should be eradicated by operation. The patient is allowed to go about with crutches or a Thomas' knee splint if articular symptoms are absent or have subsided.

When the disease is diffuse and resists conservative treatment, operation must not be delayed. The choice lies between arthrectomy and excision. In excising the joint the articular surfaces of the constituent bones are removed, and it may be necessary to take away the whole of the astragalus.

Amputation should be restricted to rapidly progressing disease in adults with diffuse suppuration and visceral tuberculosis, and to cases which have relapsed after excision. Whatever method of amputation is employed, it is essential that the infected tissues should be completely removed to avoid recrudescence in the stump, which would necessitate re-amputation at a higher level.

The other diseases of the ankle include *pyogenic*, *gonorrhœal*, *rheumatic*, *gouty* and *hysterical* affections, *arthritis deformans*, and *Charcot's disease*. The last-named is generally associated with a rapid and painless disintegration of the bones of the ankle and tarsus, resulting in great deformity and loss of the arch of the foot—sometimes associated with perforating ulcer of the sole.

Tuberculous disease in the *tarsus* and *metatarsus* has been considered in the general article on diseases of bone.

CHAPTER XXXI.

THE DEFORMITIES OF THE EXTREMITIES.

Congenital dislocation of hip—Paralytic deformities—Contractures and ankyloses of hip—Coxa vara—Congenital dislocations of knee and patella—Genu recurvatum—Paralytic deformities—Contractures and ankyloses of knee—Genu valgum and genu varum—Congenital deformities of leg—Bow-leg—Club-foot: *Talipes equino varus—Pes equinus—Pes calcaneus—Pes calcaneo-valgus and varus—Pes cavus*—Flat-foot and pes valgus—Metatarsalgia—Hallux valgus and bunion—Hallux varus—Hallux rigidus and flexus—Hammer-toe—Hypertrophy of toes—Supernumerary toes—Webbed toes—Congenital absence of clavicle—Winged scapula—Congenital paralytic deformities of shoulder—Deformities of elbow—Club-hand—Deformities of wrist—Deformities of fingers—Dupuytren's contraction—Polydactylism.

In this chapter we shall study those abnormalities in the attitude and form of the limbs—whether congenital or acquired—which are capable of being benefited by mechanical or operative treatment. This subject constitutes an important branch of what is known as orthopædic surgery.

DEFORMITIES OF THE LOWER EXTREMITIES.

Congenital Dislocation of the Hip.

This is the commonest of all congenital dislocations. Its frequency varies in different countries, being much greater on the continent of Europe than in Britain. It is sometimes hereditary, and it may be associated with other congenital deformities, such as club-foot. It is seven times more common in the female than in the male. It may occur on one or on both sides, but unilateral dislocation is decidedly the more frequent.

Of the many views which have been expressed regarding its etiology, that of Hoffa appears to us the most feasible. He believes that the dislocation takes place in the early months of intra-uterine life, and is probably associated with deficiency of the liquor amnii. It is predisposed to by the flexed and adducted attitude of the lower extremities of the fœtus *in utero*, and as a result of the elastic pressure of the wall of the uterus, the head of the femur is displaced and grows past the acetabulum. The acetabulum, in the absence of the head of the bone, does not develop properly, but remains flattened and shallow, so that when the child comes to put its weight on the limb, the head of the femur is pushed upwards and lies against the ilium. The greater frequency of the dislocation in the female is probably due to the fact that in the female fœtus the acetabulum faces the lateral aspect of the pelvis, while in the male it is directed more forwards.

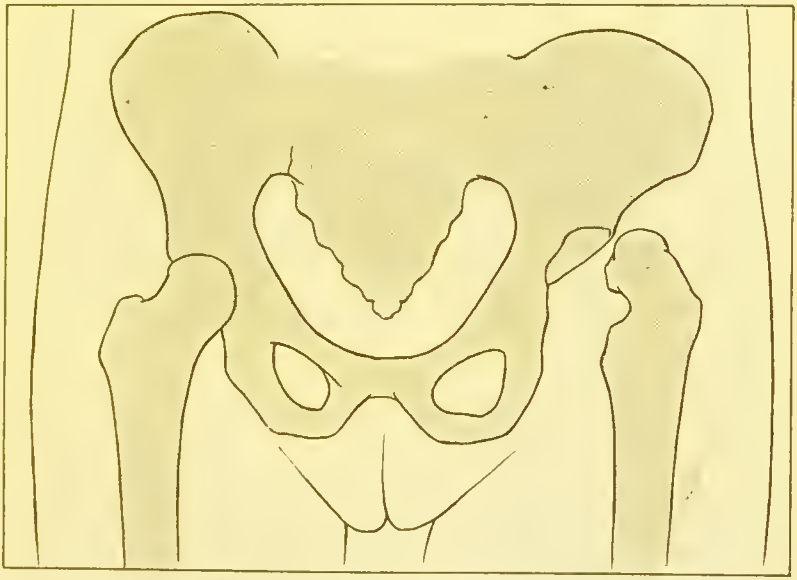

FIG. 235.—Tracing of Radiogram of Congenital Dislocation of Hip.

Pathological Anatomy.—The anatomical changes in the parts concerned vary in children of different ages. At birth the head of the femur lies just above the acetabulum, and when the child begins to walk it is, under the influence of the weight of the body, pushed still higher, till it comes to lie immediately outside the anterior superior spine. The head of the femur is often elongated or conical, its articular surface uneven, and it may be a little depressed in relation to the great trochanter. The acetabulum is narrow, elongated, and shallow, and is often partly filled up with fat and connective tissue. In children who have reached the stage of walking it is usually triangular, with the apex above and behind.

In contrast to what is observed in traumatic dislocations, a new socket is very rarely formed, because the head of the femur is separated from the ilium by the thick capsule of the joint.

With increasing years the neck of the femur becomes atrophied, and forms with the shaft an angle which approaches a right angle.

The capsular ligament is unusually thick, and is elongated, and may sometimes assume an hour-glass shape as a result of the play of the head of the femur. The ligamentum teres, which is nearly always present in the unilateral dislocation, is also elongated and strongly developed. When absent, as it frequently is in bilateral dislocations, it has probably never been developed. The muscles undergo important alterations both in length and direction ; those which pass more or less horizontally from the pelvis to the trochanter are elongated, while those which run longitudinally, including the adductors and hamstrings, are shortened.

Clinical Features.—The condition rarely attracts attention until the child begins to walk, and this may be delayed until the age of two or even three years.

In unilateral dislocation there is a decided limp and shortening of the limb on the affected side. The limp in walking is not only due to the shortening from the head of the bone sliding upwards on the ilium, but also to the alteration in the direction of the muscles, especially of the gluteus medius and minimus. These muscles, which normally maintain the pelvis horizontal, are no longer able to do so, and every time the child puts the dislocated limb to the ground and lifts the other one, the trunk suddenly lurches to the sound side. The shortening, which increases with age, and may finally amount to several inches, is partly compensated for by resting the affected limb on the balls of the toes and flexing the knee of the sound limb.

On examination of the affected limb, and especially on comparing it with the healthy side, it is observed that there is slight wasting of the buttock and thigh, and considerable prominence of the trochanter, and that the gluteal fold is straighter and deeper (Fig. 236). The limb can be moved freely in all directions except abduction. The trochanter is well above Nélaton's line. The head of the femur is absent from its normal situation, and may be felt just below or immediately to the outer side of the anterior superior spine. In young children, if the pelvis be fixed, the head of the bone may be made to glide upwards and downwards on the ilium. The pelvis is inclined forwards, and this is associated with flexion at the hip and well-marked lordosis of the lumbar spine (Fig. 237). The spine is also curved laterally with the convexity to the affected side. The lordosis partially disappears when the child lies on its back, and the scoliosis disappears on equalising the length of the limbs by placing a flat object, such as a book, under the sole.

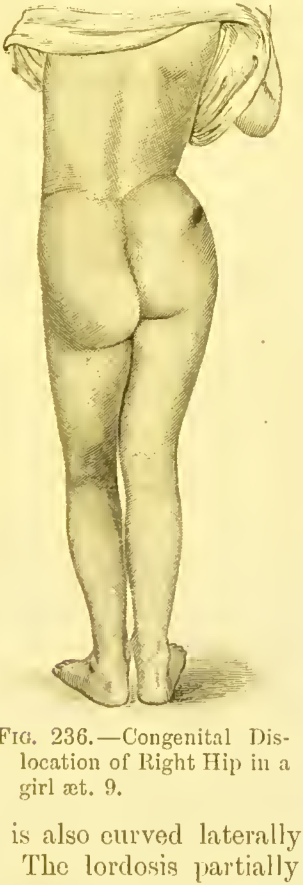

Fig. 236.—Congenital Dislocation of Right Hip in a girl æt. 9.

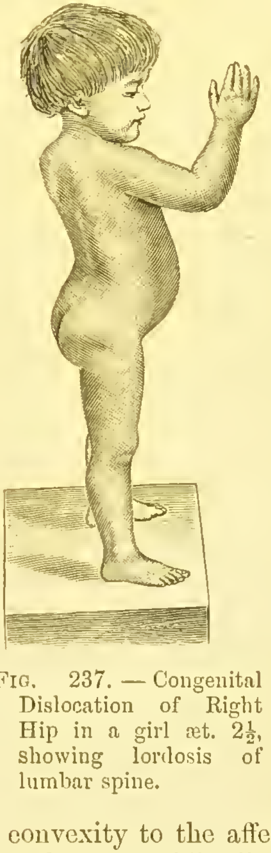

Fig. 237. — Congenital Dislocation of Right Hip in a girl æt. 2½, showing lordosis of lumbar spine.

In bilateral dislocation there is a more pronounced alteration in the attitude and gait of the patient. The trunk appears well grown in contrast to the short lower limbs, the lordosis of the lumbar spine is very marked, and is associated with undue prominence of the belly and of the buttocks. The gait is waddling, like that of a duck, the trunk lurching from one side to the other as the head of the femur glides upwards on the ilium with each step.

The *diagnosis* is easy except in young children who are very fat. In cases of rickets with marked lordosis the gait may be waddling, but the trochanter is not displaced above Nélaton's line, and the head of the bone is in its normal position. In coxa vara the limb is shortened and the trochanter is displaced upwards, but the head of the femur may be felt to be in the acetabulum, and cannot be made to move up and down; the limb is rotated out, and abduction is more restricted than in dislocation. Any doubt will be cleared up by using the X-rays (Fig. 235). In the flail joint of infantile paralysis the resemblance to congenital dislocation may be very close indeed; the muscles, however, are more wasted and are slack, and the normal attitude can be easily restored by pulling on the limb. In hip disease the movements at the joint are restricted or absent.

Prognosis.—The deformity and disability become more and more pronounced as the capsular and round ligaments become further stretched by the weight of the body in standing and walking. With increasing years the patient suffers from fatigue and pain on using the limb, and so may be unable to undertake any occupation involving much standing or walking. The sooner the affection is recognised and treated the greater is the prospect of cure.

Treatment.—The most rational and satisfactory treatment is to reduce the dislocation by manipulation, or, if this ideal result is not attainable, to displace the head of the bone into such a position that it will no longer glide upwards on the ilium. Paci, Schede, Mikulicz, Lorenz, and Hoffa have specially developed the treatment of congenital dislocation on these lines.

Reduction by Manipulation.—The child is anæsthetised; extension is applied to the leg through the medium of a hank of worsted above the malleoli and counter-extension to the trunk by means of a perineal band; the traction is gradually increased until the trochanter is brought down to the level of Nélaton's line. When this is accomplished the limb spontaneously assumes the abducted position and the prominence of the trochanter disappears, and in its place there is a marked depression. During this procedure the adductor tendons stand out like cords, and should either be stretched by firmly pressing on them with the thumbs or divided subcutaneously.

The head of the femur, having been brought down to the level of the acetabulum, is made to turn towards the socket by flexing the thigh and rotating it slightly inwards. If the flexed and slightly internally rotated limb is now abducted to the maximum degree—about 90°—the head of the femur glides over the posterior border of the acetabulum and enters the socket, often with an audible click and an appreciable vibration of the limb which indicate that the reduction has been accomplished. After reduction, the abducted limb should be rotated outwards until the head of the femur bulges the soft parts in the fold of the groin.

The limb must be maintained in the abducted position, otherwise the head tends to escape from the socket. This is secured by an accurately fitting plaster bandage, which includes the lower part of the trunk and the affected limb down to the knee.

The first bandage is changed after ten or twelve weeks, and is then renewed at shorter intervals, the angle of abduction being diminished at each renewal until the limbs are nearly parallel. At the end of six months the bandage is given up, and massage and exercises are employed; slight abduction of the affected limb is secured by raising the sole of the sound limb one-half or three-quarters of an inch. In the event of failure to reduce the dislocation on the first attempt, the limb should be fixed in plaster in the attitude of abduction and eversion for fourteen days, and then another attempt made. In bilateral cases both dislocations should be reduced at one sitting if possible; the child is then put up in a plaster bandage with both thighs abducted and flexed to a right angle. The results obtained in a large series of cases show that reduction is successful in the great majority of children under six years of age. The younger the child the greater is the prospect of success.

Although the above method of treatment does not always enable us to restore the condition to that of a normal hip, the functional results obtained are extremely satisfactory.

Reduction by Open Operation.—This should be had recourse to in cases in which reduction has failed, or in which redislocation occurs. The operation consists in exposing the joint by a lateral or anterior incision, drawing aside the muscles, dividing the capsular ligament, displacing the head of the bone, enlarging and deepening the acetabulum by means of the gouge or sharp spoon, and replacing the head in the socket. Subcutaneous tenotomy of the adductor and hamstring tendons may be necessary. The best results are obtained when this operation is performed between the third and eighth years.

In patients above the age of ten reduction is less likely to be successful by either of the preceding methods. Where, however, the patient is seriously incapacitated by the deformity, an attempt may be made to improve the existing condition of affairs. This may be accomplished by an operation which secures a firm fibrous ankylosis at the hip in the abducted position of the limb.

Paralytic Deformities of the Hip. — These usually result from infantile paralysis, and are often associated with similar paralytic deformities of the knee and ankle. When the paralysis is very extensive the hip-joint may become flail-like and useless—a condition which may be relieved by the use of a supporting apparatus or by arthrodesis. When the paralysis specially involves definite groups of muscles, the tendency is towards contracture, usually in the attitude of flexion with adduction and inversion. The contracture may finally result in a dislocation either onto the dorsum ilii or onto the pubes. The dislocation may even occur in patients who are confined to bed (Fig. 238).

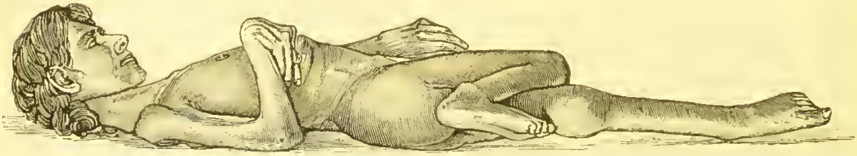

Fig. 238.—Contracture Deformities of Right Upper and Lower Limbs resulting from cerebral palsy in infancy.

The contracture may be remedied by massage, weight extension, and subcutaneous division of the shortened structures. Reduction of the dislocation is rarely possible without having recourse to an open operation, and this should be done in suitable cases.

Contractures and Ankyloses of the Hip.—In addition to the paralytic contracture above-mentioned, other forms are met with, for example, as a result of cicatricial contraction of the soft parts on the flexor aspect of the joint—such as may follow upon burns or disease of the femoral glands—or from shortening of the fasciæ, muscles, and ligaments on the flexor aspect of the joint in conditions in which the hip is maintained in the flexed position for long periods—for example, in psoas abscess, chronic rheumatism, or hysteria.

The majority, however, result from tuberculous disease of the hip-joint, and have been already considered. In a certain number of cases the contracture of the soft parts is associated with fibrous or osseous ankylosis of the joint.

Coxa Vara—Incurvation of the Neck of the Femur.—Coxa vara is an acquired deformity of the upper end of the femur, usually associated with shortening and alteration of the attitude of the limb. Attention has been directed to it chiefly by Müller, Ogston, and Kocher. Coxa vara is not a disease *per se*, but may result from any pathological condition which is capable of bringing about an alteration in the axis of the neck of the femur, whereby the head is depressed either to or below the level of the great trochanter. Several forms are recognised.

Adolescent Coxa Vara.—This, the most common clinical type, is met with chiefly in boys between the ages of twelve and eighteen. It may be associated with other deformities occurring at or near puberty—such as lateral curvature of the spine, knock-knee, or flat-foot. It is usually unilateral. The deformity and resulting disability may be the first indications of the condition, or there may be pain and stiffness at the hip before there is any deformity. When pain is an early symptom, and especially when it is also referred to the knee, the condition closely simulates hip-joint disease. The patient usually complains of being easily tired, of difficulty in kneeling and sitting, and of an increasing limp in walking.

On examination the limb is found to be shortened, and the great trochanter displaced upwards. The shortening, which may amount to as much as two inches, is estimated by applying Bryant's or Nélaton's tests. The trochanter is usually displaced backwards as well as upwards, and is unnaturally prominent. The muscles of the buttock and thigh are a little smaller and softer than on the normal side. The limb is more or less adducted, and its normal range of abduction is considerably restricted. There is also, as a rule, some degree of external rotation, so that the toes are turned outwards and the patient is incapable of completely rotating the limb inwards. Flexion is also restricted. The external rotation and adduction are partially compensated for by upward tilting of the pelvis and a certain degree of lateral curvature of the spine.

When the deformity is *bilateral*, the attitude and gait are highly characteristic, as the adducted and everted legs tend to cross each other at the knee. The attitude and gait may be of the scissors-leg type, or of that associated with certain forms of spastic paraplegia. In extreme cases the patient may be unable to walk at all, or can only do so with the aid of crutches. In the recumbent position the thighs cross each other when the lower limbs are flexed at the hip and knee.

Pathological Anatomy.—The changes in the upper end of the femur vary in different cases. There may be a simple adduction bend of the neck of the bone, so that its angle is diminished from about 125° to about 60°, or this may be combined with a forward, or less frequently with a backward curving of the neck. In the majority of cases the neck presents a curve with the convexity upwards and forwards, while its lower border is greatly shortened, so that the head of the bone may come into contact with the lesser trochanter, and the shaft is adducted and rotated outwards. Less commonly the bend involves the epiphysial junction or the upper third of the shaft. The cause of the bending is the weight of the body acting on bone which has been softened by any disease such as rickets, osteomalacia, or osteomyelitis.

Diagnosis.—The differential diagnosis between coxa vara and hip disease may present considerable difficulty. In hip disease the movements of the joint—especially the rotatory movements—are usually more restricted than in coxa vara. Skiagrams, although sometimes misleading, are often of great value. It is to be borne in mind that tuberculous disease of the joint, especially when it runs its course without suppuration, may give rise to the deformity of the upper end of the femur which constitutes coxa vara. The diagnosis from congenital dislocation of the hip can usually be made by the history, the examination of the joint and of its movements, and by the use of the Röntgen rays.

Prognosis.—The deformity may at any time become arrested, but as a rule, in the absence of treatment, it tends to increase.

Treatment.—In the early stages of the disease our efforts are directed towards the relief of pain and the prevention of deformity. The patient must either give up standing and walking, or must wear a Thomas' knee splint to take the weight off the limb. Rest in bed, with extension of the limb, is often necessary. The general health should be improved by appropriate diet and medicines, and the muscles in the region of the hip should be massaged and exercised. Cycling may be beneficial after the pains and stiffness have disappeared. Where deformity is a prominent feature and seriously interferes with locomotion, improvement can be effected only by operation. This consists in an osteotomy either through or below the great trochanter, the bone being divided obliquely downwards and inwards. The limb is then put up in the abducted position, the adductor muscles being divided if necessary to allow of this. In extreme cases it has been found necessary to excise the upper end of the femur. The after treatment includes the use of massage and gymnastic exercises.

Other Forms of Coxa Vara.—In the *rickets of childhood* coxa vara is very rare in comparison with other deformities of the skeleton. It is most often associated with pronounced eversion of both lower extremities (Fig. 239), without the capacity for abduction being necessarily restricted, and with but little interference with function. The deformity is usually recovered from if the child receives the appropriate treatment for rickets, and is put up in a double long splint with the limbs inverted and abducted.

In *arthritis deformans* of the hip-joint it is not uncommon to have considerable depression of the head of the bone and diminution in the angle of its neck, with consequent restriction of abduction. Sometimes the upper end of the shaft is curved as shown in Fig. 228.

Injuries of the upper end of the femur may result in coxa vara—*traumatic coxa vara* (Royal Whitman). Greenstick fracture of the neck of the femur and separation of the epiphysis of the head, when sustained in early childhood, may result in softening of the bone, so that it bends under the weight of the body. The deformity, which is the same as that described under adolescent coxa vara, may, however, not show itself until puberty. The treatment is carried out on the lines already indicated.

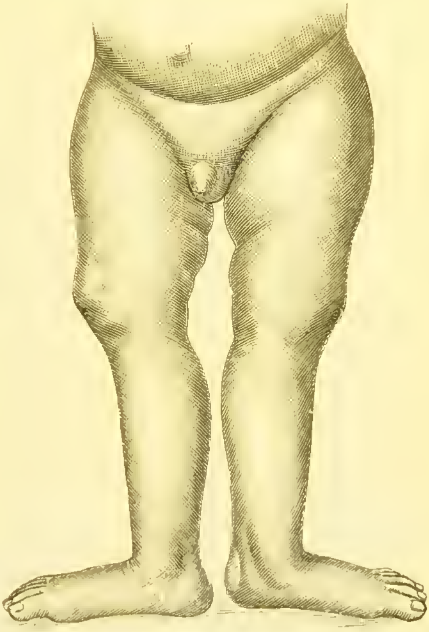

Fig. 239.—Eversion of Lower Limbs in Rickety Child, the subject of Coxa Vara.

Deformities in the Region of the Knee.

Congenital Dislocation at the knee-joint is extremely rare. The displacement may be permanent, or may occur occasionally from accidental movements of the limb. In some cases it can be produced at will by the patient or the surgeon. The dislocation is usually incomplete, and its direction varies.

Congenital Dislocation of the Patella outwards.—This may be persistent or intermittent. In the *persistent form* the patella lies on the external condyle. It may move into its normal place when the knee is flexed, or, on the contrary, it may pass further outwards and become completely dislocated (Fig. 240). In *the intermittent form* the patella lies in its normal place, but is liable to be displaced outwards when the joint is flexed; the displacement usually occurs suddenly in walking, and the patient falls to the ground, suffering intense pain. The knee-cap is readily replaced on extending the joint, but the patient is usually disabled for a day or two. The dislocation recurs at irregular intervals, and the patient is unable to prevent it. It is chiefly met with in girls, and there is usually a history that the child was late in walking and learned with difficulty. On examination, the patella is found to have an abnormal range of movement outwards, although it cannot be completely dislocated without causing severe pain. The condition is frequently bilateral, and is said to be due to an imperfect development of the external condyle of the femur. It is predisposed to by knock-knee. The following methods of operative treatment have been practised for its relief:—Displacing the attachment of the ligamentum patellæ inwards; deepening the groove for the patella on the trochlear surface of the femur; tightening up the capsular ligament along the inner side of the patella. A condition of bow-knee may be produced artificially by supra-condylar osteotomy of the femur, as recommended by Chiene, in the case of females, in whom the deformity would be hidden by the clothes.

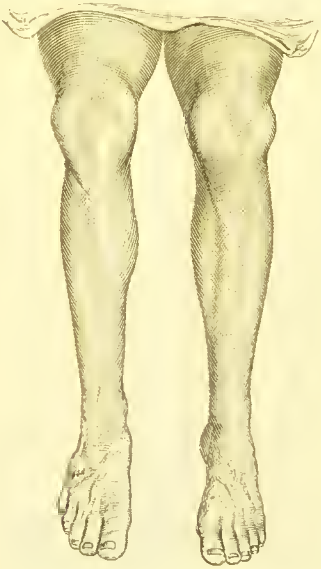

FIG. 240.—Outward Dislocation of Patellæ in a girl æt. 14.

Genu Recurvatum.—In this deformity the knee is hyperextended, the thigh and leg forming an angle which is open forwards.

It may be due to congenital dislocation of the tibia forward, especially when this is associated with absence of the patella. A more common congenital form, which is apparently the result of a faulty attitude of the lower extremities *in utero*, is met with apart from dislocation. The knee is convex backwards, and attempts to flex the joint cause pain. When the deformity is bilateral, the patellæ are usually imperfectly developed, the joints are flail-like and permit of lateral movements. The treatment is more satisfactory in unilateral cases, and consists in flexing the joint to a right angle under an anæsthetic, and maintaining this attitude by means of plaster of Paris or splints until it is well established.

The most common acquired form is the result of infantile paralysis, and will be described with the paralytic deformities.

Genu recurvatum may be met with in rickets as the result of a backward bend of the tibia immediately below its upper epiphysis—sometimes combined with an exaggerated forward curve of the femur. If there is no prospect of spontaneous rectification, the upper end of the tibia should be divided with the osteotome, and the limb straightened.

This deformity may result also from fracture or from separation of one of the epiphyses in the region of the knee, or from cicatricial contraction of the quadriceps. As a result of bone and joint disease, it is chiefly met with in neuro-arthropathies when the knee has become disorganised and flail-like.

Paralytic Deformities of the Knee.—These are commonly the result of infantile paralysis. When all the muscles acting on the knee are paralysed, the joint may be so *flail-like* that the patient is unable to stand without the aid of a crutch, or when the weight of the body is put on the limb it assumes the attitude of genu recurvatum. The treatment for the flail-joint is the use of a rigid apparatus or the operation of arthrodesis. When the quadriceps is completely paralysed, and the flexors are functionally active, the tendency is towards *contracture* of the knee in the flexed position. This is to be combated by weight extension, forcible straightening, or open division of the shortened structures in the ham. In the event of failure by these means the femur should be divided above the condyles, and the limb put up in the attitude of slight hyperextension, as this will afford the most reliable support in the upright posture.

When the quadriceps is only partially paralysed the limb acquires the attitude of *genu recurvatum*. The patient is obliged to maintain the joint in the position of extreme extension because he finds that the least degree of flexion results in the limb giving way under him. In course of time the posterior ligament becomes stretched, and the joint becomes hyperextended. The treatment consists in wearing an apparatus which ensures rigidity of the joint, or in transplanting the sartorius and tensor fasciæ femoris into the aponeurosis of the quadriceps extensor, so as to compensate for the loss of power in this muscle. In extreme cases it may be better to perform arthrodesis.

In spastic paralysis the knee is affected along with the other joints of the limb, and usually presents a condition of contracture with flexion and genu valgum (Fig. 241). In certain cases an attempt may be made by arthrodesis to render the limb capable of giving support.

Contracture and Ankylosis at the Knee.—In addition to the different paralytic forms above described, contracture may result from hysteria, from ulceration and suppuration in the poplitcal space, and from disease—osteomyelitis—in one of the adjacent bones. The greater number of contractures and ankyloses are the result of disease of the joint, and have been already described.

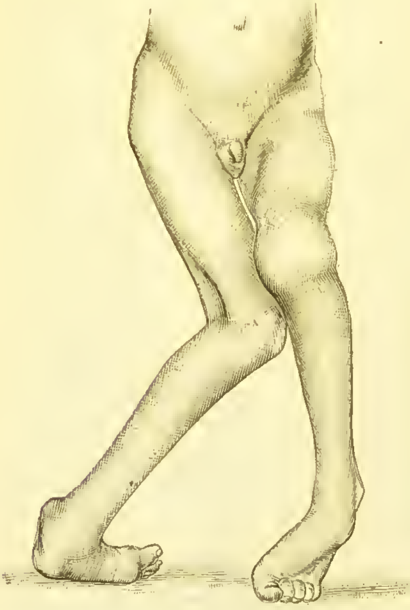

FIG. 241.—Infantile Paralysis of both Lower Limbs in a boy æt. 15, showing contracture deformities.

GENU VALGUM AND GENU VARUM.

In the normal limb, a line drawn from the centre of the head of the femur to a point midway between the malleoli passes through the centre of the knee-joint. If the line passes outside the centre of the knee-joint, the condition is one of genu valgum; if inside, it is one of genu varum (Fig. 242).

Genu Valgum—Knock-knee.—In this deformity the leg joins the thigh at an angle which is open outwards. When the affection is bilateral the projecting knees tend to knock against each other in walking, and the term X-legs may be applied to it. Our knowledge of knock-knee is largely due to the observations of Macewen and of Mikulicz, and to information afforded by the Röntgen rays.

Etiology.—While attention was formerly directed to the soft parts as being concerned in the production of knock-knee, it is now known that the primary cause is in the bones, and that it consists in an inequality of growth at the ossifying junctions of the femur and tibia. In children the essential cause is the presence of rickets, and the determining factor is a faulty attitude of the limbs in standing and walking. The legs being abducted, the weight of the body falls unequally on the outer and inner parts of the ossifying junctions, with the result that there is inequality of growth and consequent persistence and increase of the deformed attitude. In adolescents there are also changes at the ossifying junctions similar to those met with in rickets, and the determining factor is again a faulty attitude of the limbs in standing and walking.

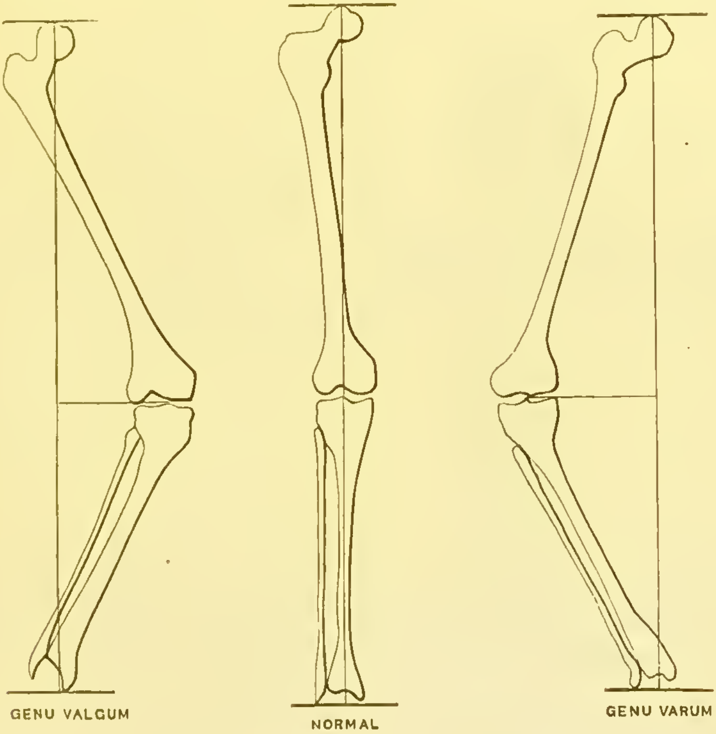

FIG. 242.

Pathological Anatomy.—Examination of the bones in knock-knee shows that in some cases the lower third of the diaphysis of the femur is lengthened on its inner side and shortened on its outer side, and that the epiphysis, itself unaltered, is fitted on to the diaphysis obliquely, so that the internal condyle appears to be increased in length and to occupy a level distinctly below that of the external condyle. In other cases the tibia shows corresponding alterations. On section of the bones the epiphysial cartilage and the zone of ossification are wider, thicker, and more irregular than normal—changes which are usually regarded as of rachitic origin.

The neck of the femur is shortened and its angle diminished. The bones of the leg are sometimes bent inwards in their lower thirds, so as to compensate partly for the valgus deformity at the knee. The articular cartilage over the external condyle and the external semilunar cartilage are usually thickened. In pronounced cases the patella and quadriceps tendon are displaced outwards. The changes in the soft parts are secondary to those in the bones. It has been shown by Symington that the biceps tendon and ilio-tibial band are shortened and more prominent as a result of the approximation of their attachments, and they are also displaced outwards. The sartorius and gracilis are displaced backwards, so that they descend behind instead of on the inner side of the knee. The popliteal artery lies on the back of the external condyle instead of in the hollow between the condyles, and the internal popliteal nerve is displaced even further outwards. The capsular and other ligaments are usually slack, so that the joint is wobbly and easily hyperextended. There is often a little effusion into the joint.

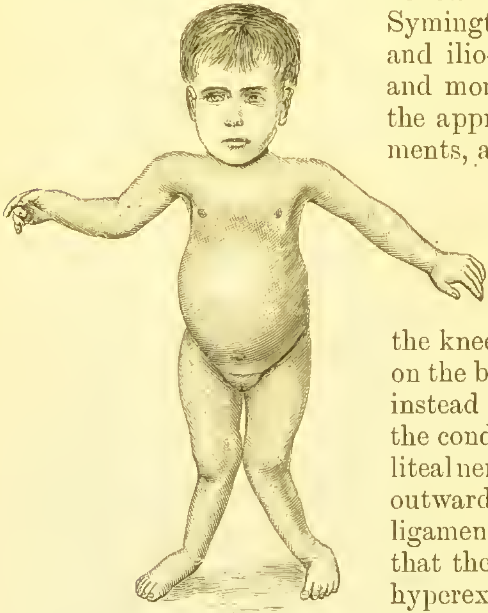

FIG. 243.—Knock-knee in Child æt. 7, the subject of Rickets. The patient was unable to walk without support.

Clinical Features.—In the infantile form (Fig. 243) the knock-knee is very commonly associated with signs of rickets in other parts of the skeleton, and especially with bending of the tibia and femur, and in extreme cases the child may be unable to walk. In the majority of cases of adolescent knock-knee the patient seeks advice because of the deformity alone, but in addition he may complain of pain after exertion, especially at the inner side of the epiphysial junctions, of being easily tired, and of his incapacity for any laborious occupation, or even for one involving much standing.

The deformity is about as frequently bilateral as unilateral. There may be knock-knee on the one side and bow-knee on the other. The valgus attitude disappears on flexion of the knee as the result of simultaneous outward rotation of the limb at the hip. It is usually possible to hyperextend the knee, and in the extended position to rotate the leg out to a greater extent than is normal. In unilateral knock-knee the affected limb is a little shorter than its fellow, but the patient compensates for this by depressing the pelvis on the affected side. In many cases of the adolescent type the bones are large and coarse and badly formed, and there is frequently an obtuse or pointed spinous process projecting downwards from the inner tuberosity of the tibia.

In bilateral adolescent knock-knee the patient abducts the thigh at each step and rotates the limb outwards at the hip, so as to allow the projecting knees to pass each other more easily, and to disguise the deformity. He usually supinates or inverts the foot, and turns the toes inwards, with the object of bringing the whole length of the outer border of the sole into contact with the ground. Flat-foot is the exception. The boots usually show evidence of the toes being turned in, and they are more worn along the outer than along the inner border of the sole and heel.

Prognosis.—While there is some prospect of spontaneous recovery in children under six years, the usual tendency is for the deformity to increase until the skeleton reaches maturity at the age of eighteen or twenty.

Treatment of Infantile Knock-knee.—The general treatment is directed towards curing the rickets. So long as this disease is active the child should not be allowed to stand or walk. The limbs should be strengthened by douching and massage twice daily, finishing on each occasion with manipulations which are directed to undoing the deformity. Of the numerous forms of apparatus devised for knock-knee, the simplest consists of a light padded splint applied on the outer side of each limb, extending from the iliac crest to three inches beyond the foot. The splint is fixed above and below by bandages, and the projecting knee is drawn towards it by a few turns of elastic webbing. In pronounced cases these splints are only removed for purposes of massage and bathing. In the mildest cases they are only worn when the child is indoors. A modified form of Thomas' hip splint is efficacious, but requires careful supervision. A simpler plan of treatment, specially applicable to hospital out-patients, is to straighten the limbs as far as possible under chloroform and envelop them in plaster of Paris. The procedure is repeated at intervals of three weeks until the legs are quite straight. Whatever plan is adopted, it must be persevered with for at least six months, until the bones have become rigid.

If the child is approaching the age of five or six before it comes under treatment, or if the deformity does not yield to treatment by splints, it is better to straighten the limb by osteotomy, taking precautions, however, to prevent relapse of the deformity until the softness of the bones has entirely disappeared.

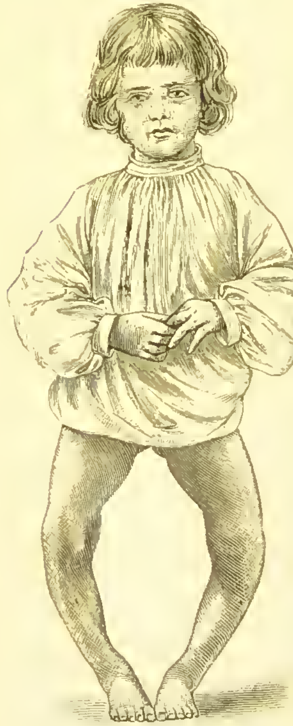

FIG. 244.—Bow-knee in Rickety Child.

In *adolescent knock-knee* the conditions are very different from those obtaining in the child. Splints and apparatus—especially such as allow of the patient walking about—are of little or no value. If the deformity is at all marked there should be no hesitation in recommending osteotomy. If the femur is chiefly concerned, it should be divided above the condyles. If the tibia is mainly responsible, it should be divided below the epiphysis, along with the fibula. In case of failure to remedy the deformity completely by one of these procedures, it should be supplemented or followed by the other. It is very rarely necessary to divide the tendon of the biceps or the ilio-tibial band. The patient gains in height by the operation, but a considerable time usually elapses before his capacity for walking attains the normal standard.

Other forms of genu valgum than those described as resulting from rickets are relatively rare. There is a congenital form arising from faulty position of the limbs *in utero*; a traumatic form following fracture or epiphysial separation in the region of the knee: and a paralytic form usually combined with flexion in cases of spastic paralysis. Finally, genu valgum may be a result of osteomyelitis of the lower end of the femur, or of disease in the knee-joint, such as tuberculosis, arthritis deformans, or Charcot's disease.

Genu Varum—Bow-knee.—In this deformity, which is in nearly every respect the converse of genu valgum, the leg joins the thigh at an angle which is open inwards. It is almost invariably bilateral and of rachitic origin (Fig. 244). It is frequently associated with bow-legs. The tibia takes a greater share in its production than the femur. Although an ungainly deformity, it is much less frequently the source of complaint than knock-knee, because it does not interfere with locomotion —as a matter of fact, the subjects of it, although short in stature, are unusually sturdy on their legs.

Treatment is carried out on the same lines as in genu valgum. If an operation is required to straighten the limbs, the tibia should be divided below the knee in the first instance. In adolescents it may also be necessary to divide the fibula. If by this the deformity is not corrected, the femur should be divided above the condyles. It may even be necessary to divide the shafts of the tibia and fibula, especially where there is bow-leg as well. This should be performed, however, at a subsequent operation.

Congenital Deficiencies of the Bones of the Leg.—The *tibia* may be partly or completely absent. In either case the leg is short and stunted, the knee is flexed, the foot occupies the position of extreme equino-varus, and the limb is useless. The exact nature of the defect is demonstrated by the Röntgen rays. When the upper end of the tibia is absent, the fibula articulates with the external condyle of the femur. The operative treatment is difficult; it aims at correcting the flexion at the knee, the equino-varus of the foot, and substituting the fibula for the absent tibia. The deficiency of the upper end may be compensated for by implanting the head of the fibula between the condyles of the femur, and that at the lower end by splitting the fibula so as to form a socket for the astragalus. If the lower end of the tibia is present, it may be prepared as a socket for the fibula after cutting this bone across. If an operation fails or is inapplicable, the deformed leg may be amputated to allow of the patient using an artificial limb.

The *fibula* may be partly or completely absent. The clinical appearances depend upon the condition of the tibia. When the tibia is normal, the most notable feature is the absence of the outer ankle bone, and the extreme valgus attitude of the foot. More commonly the tibia presents a sharp forward bend just below its middle, and the overlying skin presents a dimple or scar-like depression. This has usually been regarded as an intra-uterine fracture of the tibia, but the observations of Hoffa negative this view. Both the bend of the bone and the depression on the skin would appear to be due to pressure exercised upon the leg from without by means of an amniotic band or adhesion. As the child increases in years the leg fails to grow, the deformity becomes more pronounced, and the toes become pointed. If the tibia is markedly bent, it may be straightened by osteotomy. If the ankle is unstable as a result of the absence of the external malleolus, it may be artificially ankylosed, or the lower end of the tibia may be split vertically so as to make a socket for the astragalus. In either case the foot is placed in the equinus attitude to compensate for the shortening of the leg. Deficiency of the tibia is frequently associated with imperfect development of the great toe—deficiency of the fibula with absence of the outer toes and their metatarsal bones.

Volkmann's Supra-malleolar Deformity.—This term is applied to a congenital deficiency in the development of the bones of the leg, and especially of the fibula, as a result of which the articular surface is oblique and the foot deviates to one or other side. The foot usually occupies a valgus position, the sole looking outwards, and only its inner border being in contact with the ground. It is to be treated by supra-malleolar osteotomy.

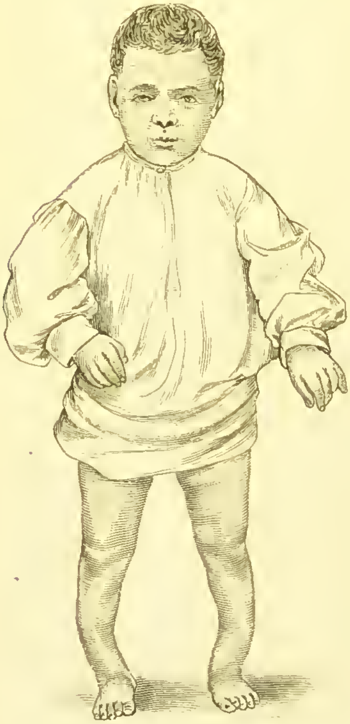

Fig. 245.—Bow-leg in Rickety Child.

Rickety Deformities of the Bones of the Leg—Bow-legs.—These are very common in children under five, and they are nearly always bilateral and symmetrical. They may occur before the child is able to walk, the bones bending in the attitude in which they are habitually placed—over the nurse's knee, for example, or as they are crossed underneath the child in sitting. In children who are able to walk, the deformity is due to the weight of the body acting on the softened bones. In either case the bending may be increased by the traction of muscles, and sometimes by the occurrence of greenstick fracture. The most common deformity is a uniform curvature of the bones outwards and somewhat forwards, or a more acute bend in the lower thirds of their shafts. In some cases the chief curvature is forwards. The ungainliness in walking may be added to by flat-foot. The deformity of the legs may be associated with knock-knee or bow-knee. Backward curve of the upper end of the tibia has been described as one of the causes of genu recurvatum.

The chances of natural straightening of the curvature are very considerable in children under six years, and especially in those who are actively growing. The most extreme and persistent deformities are met with in rickety dwarfs.

Treatment.—Under the age of six the bones will probably straighten if the child is treated for rickets and kept off its feet. Well-padded external splints should be applied as recommended for knock-knee, and these should be taken off at intervals for massage and douching, and manipulations tending to undo the curvature. In order to save time the bones may be forcibly straightened under chloroform. Above the age of six, when the bones have become hard, they must be divided at the seat of greatest curvature. In the tibia an oblique or vertical osteotomy usually suffices, but it may be necessary to remove a wedge of bone. The fibula may be forcibly straightened or may require to be divided through a separate incision. In aggravated cases it may also be necessary to divide the tendo Achillis.

The deformities of the legs in inherited syphilis, ostitis deformans and osteomalacia have already been described.

DEFORMITIES OF THE FOOT.

Various deformities are met with in the region of the ankle and tarsus. The term "talipes" is commonly used to include all these, but will be here restricted to that form in which the heel is more or less elevated, and the foot supinated so that it rests on its outer border—*talipes equino-varus or club-foot.* In *pes equinus* the foot is in the position of plantar-flexion, and the patient walks on the toes. In *pes calcaneus* the foot is dorsiflexed so that the tip of the heel comes in contact with the ground. This deformity may be combined with eversion of the foot, *pes calcaneo-valgus*, or with inversion, *pes calcaneo-varus.* When the instep is unduly arched the terms *pes cavus*, *pes arcuatus* or *hollow claw-foot* are employed; while loss of the arch constitutes *flat-foot* or *pes valgus.*

CLUB-FOOT.

Talipes Equino-varus.—This deformity is present at birth in three-fourths of the total number of cases. It may be acquired, chiefly as a result of infantile paralysis.

Congenital talipes equino-varus is a very common malformation (Fig. 246). It may be met with in several members of one family, and is sometimes associated with other congenital deformities such as hare-lip or spina bifida. It is twice as common in the male as in the female, and is more frequently bilateral than unilateral. Its etiology is still a matter of conjecture. It may be pointed out, however, that the fœtal foot is very easily moulded into abnormal attitudes by external pressure, such as might be exercised by the wall of the uterus. In a limited number of cases there are indications of such pressure over the bony prominences of the foot, in the shape of circumscribed scar-like areas in which the skin is atrophied.

Pathological Anatomy.—In well-marked cases the long axis of the foot presents a concavity towards the inner side, the maximum point of the curve being opposite the mid-tarsal joint. Only the outer border of the foot touches the ground when the patient attempts to stand, and the weight is borne on the base of the fifth metatarsal, the cuboid, and the greater process of the os calcis.

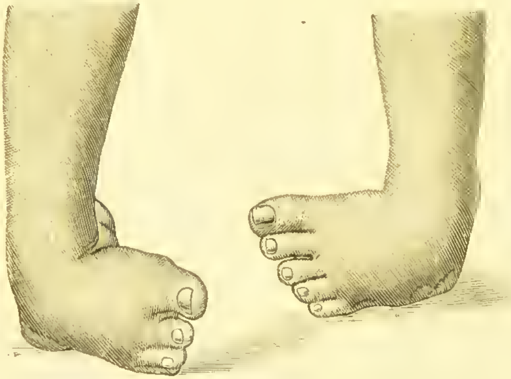

FIG. 246.—Congenital Talipes Equino-varus in an Infant.

The individual tarsal bones, especially the astragalus and os calcis, are altered in shape as well as in their relations to one another and to the tibio-fibular socket. The scaphoid and cuboid are rotated inwards around the anterior ends of the astragalus and os calcis respectively, and the tubercle of the scaphoid comes to lie very close to the internal malleolus. The lower third of the tibia is rotated inwards on its long axis.

The changes in the soft parts follow the general law that tissues which are relaxed become shortened, while those which are put on the stretch become lengthened. All the tissues on the inner, concave, side of the foot are shortened. The ligaments most affected are the internal lateral and the posterior ligaments of the ankle, and the inferior calcaneo-scaphoid ligament. There is also shortening of the muscles inserted into the tendo Achillis, and to a less extent of the tibiales anticus and posticus. The extensor tendons on the dorsum are displaced inwards.

Clinical Features.—*In children who have not walked* the degree of deformity varies in different cases. Sometimes it is very slight. In pronounced cases the foot is turned inwards and forms a right angle with the leg; the sole looks backwards and the inner border looks upwards. The foot appears shortened because it is curved on itself, the heel is narrow and more vertical, the inner malleolus is obscured by the approximation of the scaphoid, and the external malleolus is unduly prominent.

In extreme cases the supinated foot may form an acute angle with the leg, and there is frequently a deep transverse depression across the sole, the result of contraction of the plantar fascia—a distinctive feature of the congenital form of club-foot (Fig. 247).

In children who have walked the deformity of the foot becomes more pronounced. The dorsum of the foot is markedly uneven, partly because of the prominence of the individual tarsal bones, and especially of the head of the astragalus and greater process of the os calcis, and partly because of a depression over the neck of the astragalus. Instead of resting on its outer border, the foot may finally rest on the dorsum, the sole looking upwards and backwards. While the skin over the heel remains comparatively thin and delicate, that covering the outer border and dorsum of the foot becomes the seat of callosities, beneath which adventitious bursæ are formed. These bursæ are liable to become inflamed, and are then the source of great suffering, and if they suppurate they may cause persistent sinuses. The muscles of the leg and foot, although not paralysed, undergo atrophy from disuse. In walking the patient lifts one foot over the other in an ungainly and laborious manner, as if walking on stilts.

In adults these features are still further aggravated, and there are permanent changes in the bones.

Prognosis.—The slighter degrees of club-foot may be completely corrected. The severe forms may be improved so as to give the patient a useful limb. The younger the patient, the more easily and completely is the deformity rectified.

Treatment.—This should be commenced as soon as the viability of the infant is beyond question. Manipulations directed towards the correction of the deformity should be carried out twice or thrice daily. The limbs should also be massaged and bathed. In the intervals between the manipulations, the foot should be maintained in the corrected attitude by bandages. At the end of two or three months assistance may be derived from the use of splints,—either a simple lateral poroplastic or aluminium splint with a foot-piece, or some form of special apparatus which aims at correcting the deformity. If this regime is systematically persevered with from within a few days after birth, by the time the child is able to put its foot to the ground the deformity will be so far corrected that some form of special apparatus can be worn—the club-foot shoes devised by Scarpa and Sayre are those most generally useful.

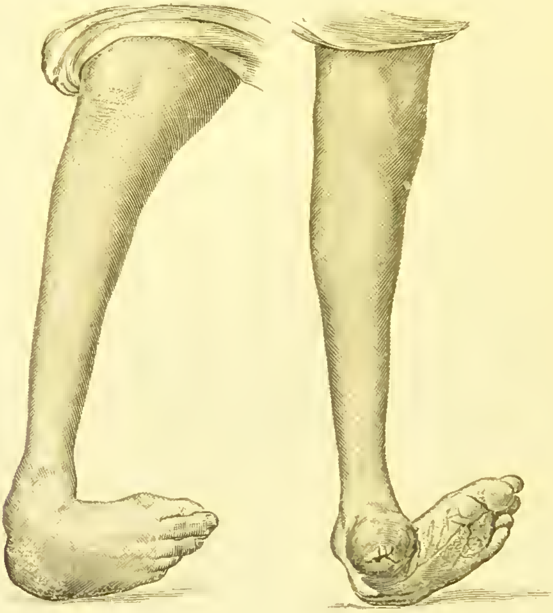

Fig. 247.—Congenital Talipes Equino-varus, in man æt. 24.

The weight of the body also acts in the direction of correcting the deformity.

If the equinus element resists correction, the tendo Achillis should be divided.

Persistent inversion is best overcome by strapping the feet every night to a wooden board in the attitude of extreme eversion. The manipulations and massage must be persevered with for at least another year on account of the tendency towards relapse.

Tenotomy and Forcible Correction under Chloroform.—If no treatment has been carried out in early infancy, more energetic measures are required to correct the deformity. We have now to deal not only with the contracted soft parts, but with changes in the bones, resulting from their having grown in the deformed attitude.

The soft parts most requiring division are the tendo Achillis, the internal and posterior ligaments of the ankle, the plantar fascia, the calcaneo-scaphoid ligaments and the tibialis posticus tendon. The varus deformity may be corrected by laying the foot on its outer side on a padded triangular wooden block, and pressing forcibly on the anterior and posterior ends of the foot so as to undo the curve on its inner side and allow of abduction of the foot; this is usually attended with cracking as the shortened ligaments give way. The equinus is then corrected by forcibly dorsi-flexing the foot until the deformity is over-corrected. A plaster of Paris case is then applied to maintain the attitude of over-correction. Some surgeons prefer to correct the deformity in stages instead of at one sitting; in this case the equinus is left to the last. In older children the strength of the hands is usually insufficient and mechanical wrenches may be employed, such as those devised by Thomas, Bradford, or Lorenz. Inversion of the lower limbs as a whole may be corrected by fixing the feet to a board as already described.

Operative Treatment.—This is usually required in cases which have been neglected in infancy.

Phelps' operation, which consists in open division of the soft parts on the inner aspect of the foot, is indicated in moderately severe cases of club-foot in which the bones are still to a large extent cartilaginous. Having rendered the foot bloodless, and having divided the tendo Achillis and posterior ligament of the ankle subcutaneously, a transverse incision is made across the inner, concave aspect of the foot opposite the astragalo-scaphoid joint, dividing everything down to the bone, the foot meanwhile being forcibly abducted, everted, and dorsi-flexed. The gaping wound is then closed by a flap of the redundant skin dissected up from the dorsum, and the foot is secured in the over-corrected attitude.

Resection of a wedge from the tarsus (Davies Colley, 1876) is reserved for the most severe cases in which the shape and rigidity of the bones absolutely prevent correction of the deformity. A curved incision is made on the outer side over the most prominent part of the convexity of the tarsus, the soft parts are separated and drawn aside, and by means of an osteotome a wedge of bone, sufficiently large to admit of over-correction of the deformity, is removed. The base of the wedge is on the outer aspect and includes part of the os calcis, cuboid and astragalus, while its apex is on the inner aspect of the scaphoid. The tendo Achillis and tibialis posticus are divided with a tenotomy knife. The wound is closed and the foot maintained in position by splints or plaster of Paris.

In the case of children before the tarsal bones have become completely ossified, Ogston has suggested that, instead of removing a wedge from the tarsus, the osseous nuclei of the individual bones should be gouged out and the cartilaginous shell left. In this way the intertarsal joints are not interfered with, the cartilaginous tarsus can be moulded so that when ossification is completed the bones differ but little from the normal.

Removal of the astragalus is an alternative operation to resection of the tarsus, and yields at least equally good results.

After any of these operative procedures, manipulations, massage, exercises, electrical stimulation of the muscles and the wearing of some apparatus must be persevered with for at least twelve months. Failures are due to not over-correcting the deformity completely in the first instance, and to neglect of after-treatment.

Finally, *amputation* by Chopart or Pirogoff's method may be called for.

Acquired Talipes Equino-varus.—This develops as a result of disease or injury in a foot which was previously healthy. In contrast to the congenital form, it is said to be equally common in the two sexes and is frequently unilateral.

In the great majority of cases it results from *infantile paralysis*. When this specially affects the extensor and peronei muscles the patient is unable to dorsi-flex and abduct the foot, and it hangs with the toes pointed and the sole turned in. At first the joints are quite flaccid, and the attitude can be easily corrected by manipulation. In the course of time, however, the opposing muscles—those inserted into the tendo Achillis, the tibialis posticus, and the long flexors of the toes—become shortened. There is also secondary contraction of the plantar fascia and of the ligaments on the inner side of the foot, and the deformity is thus rendered permanent. The bones are also altered in their shape and mutual relations, the astragalus being displaced forwards so that a large portion of its trochlear surface protrudes from the tibio-fibular socket. The skin of the foot is cold and livid, and readily suffers from pressure sores. The whole limb is ill-developed, and may be shorter than its fellow, and the paralysed muscles are wasted and give the reaction of degeneration. A similar deformity may result from section of the external popliteal nerve, from the peroneal form of progressive muscular atrophy, and from peripheral neuritis.

The *treatment* of talipes equino-varus due to infantile paralysis varies in different cases. If the deformity is easily corrected, and the paralysis is confined to the extensor and peronei muscles, satisfactory results are obtained by re-enforcing the paralysed muscles by those which are still active—*transplantation of tendons* (Nicoladoni). For example, the tendo Achillis may be split longitudinally, one-half of it cut across and attached to the distal end of the divided peroneus longus; or the flexor longus hallucis may be spliced into the tibialis anticus or the tibialis posticus into the extensor longus digitorum.

If the paralysis is more widely distributed, and the ankle and tarsal joints are flail-like, it is better to ankylose the calcaneo-astragaloid and ankle-joints by *arthrodesis* (Albert). It may be necessary to divide the plantar fascia and other structures which have undergone secondary shortening.

The after-treatment is of great importance; it consists in massage, douching, exercises, and electric stimulation of the muscles. As great improvement usually results from the use of the limb, the patient should be got on to his feet as soon as possible.

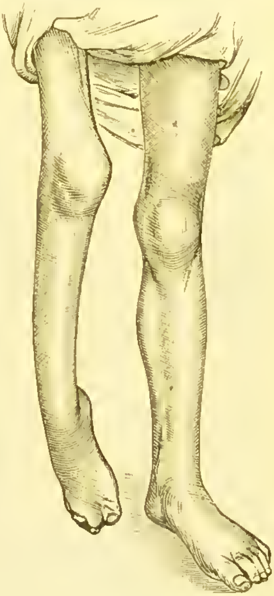

Fig. 248.—Infantile Paralysis of Right Lower Extremity in a girl æt. 15. The limb is short and wasted, and the foot is in the position of equino-varus.

The equino-varus which results from *spastic paralysis* is much less frequently met with. In contrast to the flaccid condition presented in cases of infantile paralysis, the muscles are here the seat of a persistent spasm which gradually merges into contracture. Deformity results from certain groups of muscles—the plantar flexors and invertors—getting the upper hand and distorting the foot into the equino-varus attitude (Fig. 241). The heel is markedly drawn up, the anterior part of the foot is adducted and inverted at the mid-tarsal joint. The muscles are tense and rigid, and the tendon reflexes are exaggerated. The condition is frequently bilateral, and is often associated with other deformities of the lower limb and with a characteristic spastic gait. In selected cases, considerable improvement may be brought about by division of the tendons of the shortened muscles. In severe cases it may be necessary to resect a portion of the tarsus or to remove the foot by Pirogoff's amputation.

Lastly, deformities resembling talipes equino-varus may result from injuries in the region of the ankle, from joint affections, and from cicatricial changes following extensive burns and ulcers.

The occurrence of varus without equinus is so exceptional as not to call for separate description.

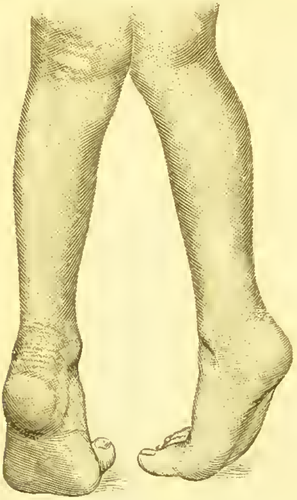

FIG. 249. — Bilateral Pes Equinus in a boy æt. 7, the result of spastic paralysis.

Pes Equinus.—This deformity consists in plantar-flexion of the foot so that in typical cases the patient walks on the balls of the toes (Fig. 249). It is nearly always acquired. It most commonly results from infantile or from spastic paralysis. In *infantile paralysis* it is most often unilateral (Fig. 250). If the muscles in front of the leg alone are paralysed the heel is drawn up by the unopposed contraction of the calf muscles. If all the muscles of the leg are paralysed, the anterior part of the foot drops into the equinus attitude by its own weight.

In *spastic paralysis* the deformity is frequently bilateral and is usually accompanied by excessive arching of the foot (pes cavus) from plantar-flexion at the mid-tarsal joint, and by hyper-extension of the first phalanges and plantar-flexion of the second and third phalanges of the toes—"clawing of the toes."

Among the less frequent causes of pes equinus mention may be made of nerve lesions such as peripheral neuritis, injuries and diseases in the region of the ankle where the foot has been allowed to remain for long periods in the attitude of plantar-flexion. In a limited number of cases, the equinus attitude is adopted by the patient in order to compensate for shortening of the limb.

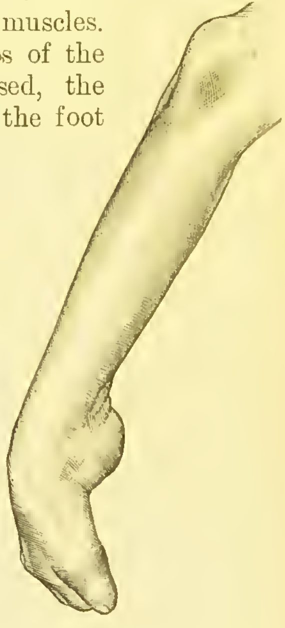

FIG. 250.—Extreme Form of Pes Equinus in a girl æt. 8, the result of infantile paralysis.

Clinical Features.—In the mildest cases the patient is able to bring the foot to a right angle, and the condition is easily overlooked. In average cases the heel is raised off the ground, and the foot rests on the balls of the toes. In extreme cases, and especially where the extensors are completely paralysed, the toes may be flexed towards the sole, and the foot rests on the dorsum. The patient suffers from painful corns and callosities, and from inflammation in the newly-formed bursæ. When unilateral, if the affected limb is longer, the patient compensates for this by flexing the knee and throwing the limb outwards in walking. In severe cases, especially where both limbs are affected, the patient may be entirely dependent on crutches.

The astragalus projects on the dorsum, the anterior part of its trochlear surface escapes from the tibio-fibular socket, and the os calcis is drawn up so that it comes into contact with the bones of the leg.

Shortening of the soft parts affects chiefly the muscles inserted into the tendo Achillis, the posterior ligament and posterior parts of the lateral ligaments of the ankle. The fasciae, ligaments and muscles of the sole of the foot are also shortened. The flexors of the toes, the tibialis posticus and peroneus longus are shortened to a less degree.

Treatment.—Of all the deformities of the foot, pes equinus is the one most easily rectified. The treatment is conducted on the same lines as in talipes equino-varus. In recent cases a great deal may be done by regular manipulations, massage, exercises and electricity, and by the wearing of some corrective splint or apparatus between times. In cases of paralysis limited to the extensors their function may be restored by transplantation of the peroneus longus or the tibialis posticus.

In well-marked cases it is necessary to divide the shortened structures, and especially the tendo Achillis. Instead of cutting this straight across, it should be divided as follows. The tenotomy knife is introduced on one side of the tendon close to its insertion, and is made to cut half-way across it. The knife is again introduced one inch higher up on the opposite side of the tendon, and is made to cut across the other half. On forcible extension the tendon readily yields to the desired extent. The deformity is then forcibly corrected and the limb encased in plaster. The excessive arching of the foot (pes cavus) and the clawing of the toes usually disappear when the equinus is corrected, but it may be necessary to divide the extensor tendons, especially that of the great toe, and also the plantar fascia.

In aggravated cases of long standing the bones must be attacked, as, for example, by excising the astragalus. Arthrodesis of the ankle and calcaneo-astragaloid joints may be indicated where these joints are flail-like. Amputation is reserved for cases which are otherwise hopeless. When the deformity is compensatory to shortening of the limb, it is usually said to be a mistake to correct the equinus. Experience shows, however, that in young patients the growth of the limb is stimulated by walking on the limb after the deformity has been corrected.

Pes Calcaneus.—In this deformity the foot is dorsi-flexed at the ankle-joint. It may occur by itself, or along with eversion —*pes calcaneo-valgus*, or with inversion of the foot—*pes calcaneo-varus*.

Pes calcaneus may be congenital or acquired. In the *congenital form* the deformity is frequently bilateral. There is dorsi-flexion at the ankle-joint, and if forcible plantar-flexion is attempted, the extensor tendons stand out prominently. In marked cases the long axis of the os calcis is vertical, the tendo Achillis lies in close contact with the tibia, and the hollows on either side of the tendon are absent. The peronei are displaced from their grooves, and may lie in front of the external malleolus. Treatment is conducted on the same lines as in other congenital deformities of the foot. Corrective manipulations are commenced within a few days after birth, and a mouldable splint is worn between times. When the child begins to walk there is a natural tendency towards recovery. In severe cases it may be necessary to divide the contracted tendons—the extensor digitorum, the extensor hallucis, and, it may be also, the peroneus tertius and tibialis anticus.

In the *acquired form* the appearances are very different because the anterior part of the foot is usually flexed towards the sole, thus disguising to a certain extent the dorsi-flexion at the ankle. It is nearly always due to infantile paralysis in which the muscles of the calf are completely paralysed, and the anterior muscles are only slightly affected or escape altogether. The anterior part of the foot is flexed towards the sole by the contraction of the plantar fascia and short muscles of the sole, the heads of the metatarsals are approximated to the heel, and a deep transverse groove is formed in the sole opposite the mid-tarsal joint. The deformity presents a combination of the hollow foot—pes cavus—with pes calcaneus. The skeleton resembles that of a Chinese lady's foot.

The patient rests on the heel and on the balls of the great and little toes, the sole of the foot being so deeply hollowed that even the outer border does not touch the ground.

The treatment varies with the conditions present in each individual case. In uncomplicated paralysis of the calf muscles, the tendo Achillis may be reinforced by transplanting into it the peronei or flexor longus digitorum. If the calf muscles are not completely paralysed and the tendo Achillis is merely stretched, this tendon may be shortened by splitting it longitudinally and making the ends overlap, or its insertion may be displaced downwards. When the ankle is flail-like it may be necessary to perform arthrodesis. The cavus element in the deformity is also to be treated.

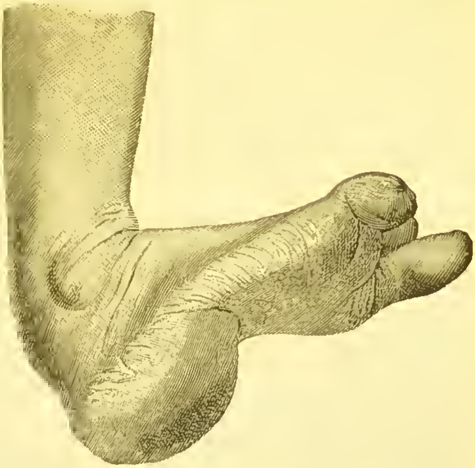

FIG. 251.—Pes Calcaneo-valgus.
(From a cast in Mr. Annandale's collection.)

Other forms of acquired pes calcaneus, such as those resulting from the contraction of scars on the dorsum, or from injury or disease of the tibia, are occasionally met with and are to be treated on general principles.

Pes Calcaneo-valgus.—This deformity, which consists in a combination of dorsi-flexion at the ankle and eversion of the foot, is fully as common as pure calcaneus (Fig. 251). The heel is depressed, the sole looks outwards, the arch of the foot is usually absent and its inner border is convex. Although it may be congenital, it is usually acquired as a result of infantile paralysis. The calf muscles are paralysed while the peronei retain their power, and along with the tibialis anticus and the extensors of the toes become secondarily contracted. Treatment is conducted on the same lines as in pes calcaneus.

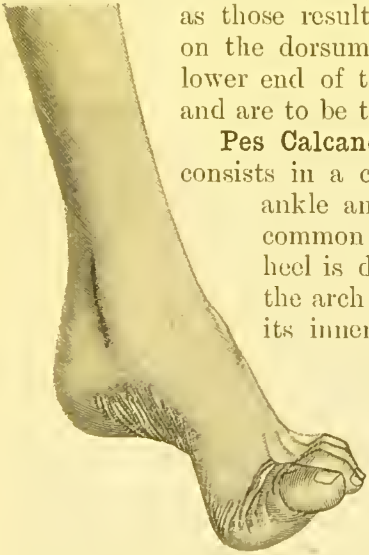

FIG. 252.—Pes Cavus in association with Pes Equinus, the result of infantile paralysis.

Pes Calcaneo-varus.—In this deformity the heel is depressed and the sole of the foot looks inwards. It is very rare.

Pes Cavus.—This deformity is also known as hollow claw-foot, pes arcuatus, or pes excavatus. The longitudinal arch of the foot is exaggerated as a result of the approximation of the heads of the metatarsal bones to the heel. There is a mild form which is congenital and sometimes inherited, and which is quite independent of paralysis. Pes cavus is most frequently met with, however, as an addition to pes equinus or pes calcaneus of paralytic origin, and has been already described. As an independent affection it has been said to result from paralysis of the extensor brevis digitorum or of the interossei, but the evidence in support of this is by no means convincing. It may occur in certain rare diseases of the spinal cord, such as Friedreich's ataxia. The name hollow claw-foot appropriately indicates the clinical appearances. The arch is exaggerated and the instep abnormally high; there is hyperextension of the toes at the metatarso-phalangeal joints, and plantar-flexion at the inter-phalangeal joints. The plantar fascia and muscles are shortened in association with the approximation of the heel and the balls of the toes. The footprint shows that neither border of the sole touches the ground. The patient may complain of pain in the instep, of difficulty in getting properly fitting boots or shoes, and of painful corns over the heads of the metatarsal bones.

Treatment should be first directed towards the equinus or calcaneus element of the deformity, for if these are corrected the cavus condition tends to get well. The contracted structures in the sole may require to be divided either subcutaneously or by the open method, as a preliminary to forcible correction.

Flat-foot—Pes Planus and Pes Valgus.

Flat-foot or splay-foot is that deformity in which the foot tends to be pronated and abducted with loss of the arch. The term *pes planus* is applicable when there is merely loss of the arch, *pes valgus* when the foot is pronated so that the sole tends to look outwards. Of all deformities of the foot, flat-foot is the one for which advice is most frequently sought. It is usually bilateral, and is about twice as common in the male as in the female. Various types of flat-foot are met with, and are known as static, congenital, traumatic, paralytic, rachitic, rheumatic, arthritic, gonorrhœal, and tabetic.

Static or Adolescent Flat-foot.—This is by far the commonest and most important variety of flat-foot (Fig. 253).

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It is called static because the essential factor in its production is the weight of the body in the erect posture, and it is called adolescent because it most frequently develops between the ages of fourteen and twenty.

It is chiefly met with in rapidly growing individuals with feeble muscles and long narrow feet, who, after leaving school, begin some occupation which entails much standing and walking —such as that of factory hands, message boys, or maid-servants. In order to continue standing for long periods the patient adopts an attitude which makes little demand on the muscles and throws nearly all the strain of the body weight on the ligaments and bones of the feet. This, which has been called by Annandale "the attitude of rest," consists in standing with the limbs apart, the knees slightly flexed, the legs slightly rotated outwards at the knee, and the feet pronated with the toes pointing outwards. In walking, the feet are similarly pronated and the toes are turned out. The most important local factors predisposing to flat-foot are weakness of those muscles of the leg and foot which normally lend support to the ankle and to the tarsal arches, weakness of the ligaments of the foot, and softness of the tarsal bones. When these conditions are present and the patient adopts a faulty method of standing and walking, the tendons and ligaments are exposed to undue strain and become stretched, the bones are altered in shape and position, and flat-foot results. The head of the astragalus is displaced inwards and is pushed in between the os calcis and scaphoid, tending to separate them from one another, stretching the inferior calcaneo-scaphoid ligament and causing the anterior part of the foot to be abducted. The plantar ligaments—especially the inferior calcaneo-scaphoid — at first become stretched and lengthened, and in course of time they become thicker and stronger (Hoffa).

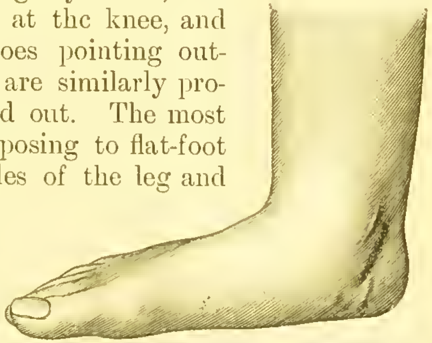

FIG. 253.—Adolescent Flat-foot.

Clinical Features.—The usual complaint is of being easily tired and of pain in the feet after walking or standing. In exceptional cases pain is entirely absent. There is usually more pain when the deformity is commencing than when it is fully developed. The pain of commencing flat-foot, before there is any loss of the arch, is liable to be wrongly ascribed to rheumatism or neuralgia, or to disease of the bones or joints. The most common seat of pain is at the inner border of the foot behind the tubercle of the scaphoid, and this is due to stretching of the inferior scaphoid ligaments. Pain is also complained of in the middle of the dorsum across the instep, from stretching of the interosseous ligaments. Later there is pain over the greater process of the os calcis in front of the external malleolus from these bones coming into contact. There may be nocturnal cramp-like pains in the legs and feet.

On examination the faulty attitude of the feet in standing and walking is usually evident. The muscles of the leg are soft, flabby, and poorly developed. When the patient is seated and asked to move the foot in different directions, there is a characteristic stiffness, ungainliness, and want of control over the movements. The foot appears longer and broader than normal, and on standing it tends to spread out with the toes extended until the entire sole is in contact with the ground. In more advanced cases the inner border of the foot is not only in contact with the ground, but may be actually convex. Below and in front of the prominent internal malleolus, the head of the astragalus forms a rounded eminence, and a little further forwards and lower still is the projection of the tubercle of the scaphoid. The eversion of the foot as a whole is best seen from behind. If the vertical axis of the leg is prolonged downwards, it approaches the inner border of the heel instead of passing through its centre. When the abduction is more pronounced, the sole looks outwards and the tendons of the peronei stand out in relief. The anterior part of the foot is displaced outwards.

Flat-foot is frequently associated with hallux rigidus or hallux valgus. The feet are usually cold and damp, and sweat excessively. The gait is slouching, and there is a want of spring and elasticity. The boots after being worn show a bulging of the instep towards the sole, greater wearing away of the sole along the inner border, and, where there is hallux rigidus, an absence of the transverse crease on the dorsum opposite the balls of the toes. Footprints may be obtained by wetting the soles of the feet and asking the patient to stand. The print of a normal foot shows only the heel, the outer border of the foot, and the balls and tips of the toes. In flat-foot the inner border appears in the print to a greater or less extent. If a permanent record is wanted to estimate the effect of treatment, the prints should be taken on smoked paper.

The sole of the foot may be everted into the valgus attitude without any loss of the arch and yet cause the ordinary symptoms and disability of flat-foot.

Treatment.—This is directed towards restoring the arch of the foot and preventing its giving way again. It necessarily varies with the stage or degree of the deformity. For purposes of treatment the following differentiation into degrees is useful. A first degree in which the arch reappears when the weight is taken off the foot or the patient rises on the balls of the toes. A second degree in which the normal attitude can be restored by the manipulations of the surgeon. A third degree in which this is only possible in narcosis. A fourth degree in which the bones are so displaced and altered in shape that correction is impossible without an open operation.

Cases of the first degree are treated on the following lines. If there is marked pain and tenderness the patient should be made to lie up. The legs and feet are douched and gently massaged. The general health is improved by a nourishing diet and by cod liver oil and tonics. When pain and tenderness have disappeared the patient is instructed how to walk and exercise the feet. In walking the inner edges of the feet should be parallel with one another; the heel should touch the ground first and then the balls of the toes. He should neither stand nor walk long enough to cause fatigue, and in standing he should alter the attitude of the feet from time to time, and occasionally rise on the balls of the toes. The following exercises, devised by Ellis of Gloucester, should be practised night and morning: (1) Rising on the balls of the toes, the toes being directed straight forwards; (2) rising on the balls of the toes, with the points of the great toes touching each other, and the heels directed out, so that the inner borders of the feet meet in front at a right angle; (3) in the same attitude, having risen on to the balls of the toes, the knee is flexed and then extended before the heel descends again; (4) while seated in a chair with the legs crossed one over the other, circumduction movements of the foot are carried out; (5) while standing the inner border of the foot is raised off the ground several times, then the patient walks to and fro on the outer border of the foot, and in the same attitude lifts one foot over the other. These exercises should be carried out with the feet bare. They should be carefully supervised until the patient thoroughly understands what is aimed at, and they should not be pushed so as to cause pain or fatigue. The patient should be fitted with well-made lacing boots. In time the limbs are further strengthened by sea-bathing, cycling, skipping, and other exercises.

In *cases of the second degree*, where the attitude of the foot is beyond the control of the patient, he should be provided with special boots or with a metal plate inside the boot. The "flat-foot boot" is a strong, well-made lacing boot, with the heel and sole thickened on the inner side so that the foot is forced to rest on its outer border (James Miller, 1846). A metal plate inside the boot, known as Whitman's Spring, is to be preferred to the rubber pads which were formerly employed. A plaster cast is taken of the sole while the foot is held in its proper position, and on this a metal plate, preferably of aluminium bronze, is modelled. This is covered with leather and inserted into the boot. The treatment described for cases of the first degree is carried out in addition.

In *cases of the third degree*, in which the deformity does not yield to the preceding measures, the patient is anæsthetised, and the foot is forcibly moved in all directions so as to stretch the shortened ligaments and to break down adhesions. It is then rotated into the extreme varus position, and fixed in plaster of Paris or to a Dupuytren's splint. The division of the tendo Achillis, and in some cases of the peronei tendons also, may facilitate the inversion of the foot. When in the course of three or four weeks the varus attitude has been secured, the treatment is continued as in the first and second degrees of the deformity.

In *cases of the fourth degree*, in which the displacement and deformity of the bones constitute an insuperable bar to correction, some form of operative treatment is indicated. Among the numerous procedures recommended we would restrict the choice to one or other of the following:—

Resection of a Wedge from the Astragalo-Scaphoid Joint (Ogston).—A longitudinal incision is made over the projecting head of the astragalus and the tuberosity of the scaphoid. These bones are cleared of soft parts, and the opposing articular surfaces are removed with the chisel in such a fashion that the astragalus is left convex and the scaphoid concave. The opposed articular surfaces of the scaphoid and internal cuneiform may also be removed. The foot is then forcibly inverted, and the cut bony surfaces are brought into contact and fixed by pegs.

Supra-malleolar osteotomy of the tibia and fibula (Trendelenburg) is equally efficient in allowing the foot to be inverted. After either operation the limb is encased in plaster, or put up in a Dupuytren splint.

Spasmodic Flat-foot.—There are cases of flat-foot in which pain and muscular spasm, chiefly of the peronei, are the predominant features. If the spasm is not allayed by rest in bed and hot fomentations, it is to be eliminated by a general anæsthetic. The foot then becomes quite loose and is easily inverted, and in this position is encased in plaster.

Paralytic Flat-foot (Fig. 254).—In typical cases this results from infantile paralysis affecting the tibialis anticus or posticus, or both. When other groups of muscles are affected at the same time, compound deformities, such as pes calcaneo-valgus, are more likely to result.

In uncomplicated paralytic valgus the inner border of the foot is depressed and convex towards the sole, and although the foot can be readily restored to the normal position by manipulation, it at once resumes the valgus attitude when left to itself. The leg is wasted, the foot is cold and livid, and the ankle tends to be flail-like. The operative treatment consists either in the transplantation of tendons — substituting the flexor longus digitorum, peroneus longus, or one half of the tendo Achillis for the paralysed tibial muscles — or in bringing about an ankylosis of the joints above and below the astragalus.

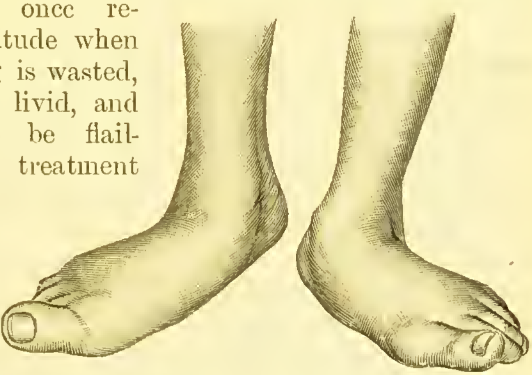

FIG. 254.—Bilateral Pes Valgus in a girl æt. 15, the result of infantile paralysis.

Traumatic flat-foot is that form which results directly from an injury. It is most often due to a fall from a height on to the soles of the feet; the ligaments supporting the arch are ruptured, and the bones are displaced either at the time of the injury or when the patient begins to walk. The arch can only be restored by a wedge-resection of the tarsus similar to that described above. After injuries about the ankle, especially a badly united Pott's fracture, the foot may be displaced outwards and pronated, the sole looking outwards (Fig. 170). Loss of the arch may follow as a result of walking on the everted foot. It is treated by supra-malleolar osteotomy of the tibia and fibula.

Other Forms of Flat-foot.—Rickety flat-foot is sometimes met with in children, in association with knock-knee or curvature of the bones of the legs, and is treated on the same lines as other rickety deformities. Flat-foot may follow upon an attack of acute rheumatism or upon diseases in the region of the ankle and tarsus, such as those resulting from gonorrhœa, arthritis deformans, tuberculosis, and Charcot's disease. There is a congenital form of flat-foot in which the sole is convex and the dorsum concave, the result of the persistence of an abnormal attitude of the fœtus *in utero.* Lastly, there is a racial variety of flat-foot, chiefly met with in negroes and in Jews, which is inherited and developmental, and which, although unsightly, is rarely a cause of disability.

Metatarsalgia.—This affection, which was first described by Morton of Philadelphia, is a neuralgia of the plantar aspect of the foot in the region of the heads of the third and fourth metatarsal bones. It is most often met with in adults between thirty and forty, and is commoner in women than in men. The patient complains of a dull aching or of an intense boring pain in the anterior part of the foot. The pain is usually relieved by taking off the boot and by rest. It may be excited by squeezing the heads of the metatarsals together or by grasping the fourth metatarso-phalangeal joint between the finger and thumb. The pain may be so severe in advanced cases as completely to cripple the patient, so that he is obliged to use a crutch. On examination, the sole may be found to be broadened across the balls of the toes, and there may be corns over the heads of the third and fourth metatarsals. Skiagrams may show a downward displacement of the head of one or other of these bones. Prints of the foot may show an increased area of contact in the region of the balls of the toes. The affection is sometimes traced to an injury, but is more often of insidious development, and is then ascribed to sinking of the transverse arch of the foot, the result of wearing badly-fitting boots. The intense pain is due to stretching of, or pressure upon, the interdigital nerves or the communicating branch between the internal and external plantar nerves. The affection is often combined with ordinary flat-foot.

Treatment.—Great improvement may result from treating the co-existing flat-foot. Pain is relieved by rest, massage, and douching. Boots should be made from a plaster cast of the foot, high and narrow at the instep so as to compress the bases of the metatarsals, with thick soles and the inner edge of the heel slightly raised. A tight bandage or strip of plaster applied round the instep before putting on the stocking may relieve pain. Where the head of one of the metatarsals is displaced it should be removed through a dorsal incision running parallel with the tendon of the long extensor.

Hallux Valgus and Bunion.—*Hallux valgus* is that deformity in which the great toe is abducted, so that it deviates outwards from the line of the first metatarsal, and comes to lie on the top of, or beneath, the second toe (Fig. 255). The head of the first metatarsal projects on the inner border of the foot, and, as a result of the pressure of the boot, an adventitious bursa is formed which, when thickened by chronic inflammation, constitutes a prominent swelling or *bunion*. It is a very common affection in civilised, and especially in urban communities, and it reaches its acme of development in adult women. It may occur on one or on both sides, and it may be associated with flat-foot.

The deformity is of very slow development, and is usually attributed to the wearing of improperly made boots. The boot which favours the occurrence of hallux valgus is one which is too short and which has pointed toes, with the apex in the middle line of the foot instead of being in line with the great toe. The pressure of the boot displaces the great toe into the valgus position, especially if a high heel is worn, as the toes are then driven forwards into the apex of the boot. A faulty method of putting the foot to the ground in walking is an important factor in the production of hallux valgus. This consists in bearing unduly on the inner side of the ball of the great toe, and in pointing the foot outwards. Once the great toe is abducted by the pressure of the boot, the deformity is increased by this method of walking.

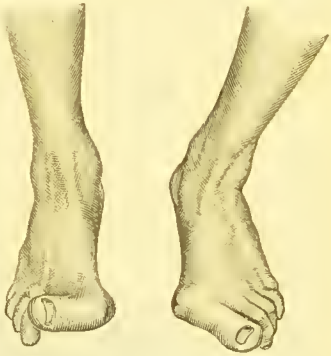

Fig. 255.—Double Hallux Valgus.

Examination of the joint in pronounced cases shows that the base of the first phalanx is displaced on to the outer aspect of the head of the first metatarsal, and the exposed head of the latter frequently shows changes like those met with in arthritis deformans, and is often the seat of periosteal overgrowth, sometimes amounting to an exostosis. Arthritis deformans is rarely the cause of hallux valgus, but may follow upon it. The distal end of the first metatarsal is displaced inwards, broadening the tread of the foot, and in severe cases its shaft is rotated on its long axis, so that its dorsal surface looks inwards; the great toe is then similarly rotated (Fig. 255). The flexor and extensor tendons and the sesamoid bones are displaced outwards. The ligaments and other soft parts on the inner side are elongated, while those on the outer side are contracted.

In some cases the patient's chief complaint is of the deformity of the foot and the consequent disfigurement of the boot; in others the complaint is of the pain and disability resulting from the sensitiveness of the joint and of the enlarged bursa over the head of the first metatarsal. The inflamed bursa, which sometimes communicates with the joint, may even suppurate and discharge for long periods, and the infection may spread to the joint.

The *treatment* varies with the severity of the deformity. In mild cases a great deal can be done by wearing properly made boots, by wearing stockings with a separate compartment for the great toe or a pad between the great and second toes, by frequent manipulations and exercises of the toes and feet, and by showing the patient how to put the foot to the ground in walking. In more pronounced cases the pain and tenderness must first be got rid of by rest and by soothing applications. At night the attitude of the toe may be corrected by a splint moulded to the inner aspect of the foot to which it is fixed by strips of plaster; the toe is then bandaged to the distal end of the splint. If there is flat-foot, this must receive appropriate treatment. In aggravated cases of long standing, the deformity can only be corrected by operation. This consists either in removing a wedge from the distal end of the first metatarsal bone, or in resecting the articular end of the bone as a whole. A curved incision is made on the inner aspect with its convexity towards the sole; the flap of skin is reflected upwards, the bursa excised, the bone bared of soft parts, and dealt with as may be necessary. If the toe still tends to be abducted, the contracted outer portion of the capsule of the joint is divided, the displaced sesamoids are removed, and the tendon of the long extensor may be detached from its insertion into the terminal phalanx and stitched to the fibrous tissues on the inner side of the proximal phalanx. A pad of gauze is inserted into the gap between the first and second toes.

Hallux Varus or Pigeon-toe.—This, which is the reverse of hallus valgus, is extremely rare, and is chiefly met with in children in conjunction with other deformities of the foot. It interferes with the wearing of boots. Treatment consists in straightening the toe and retaining it in position by a splint or plaster of Paris. The internal lateral ligament and the tendon of the abductor hallucis may require to be divided subcutaneously.

Hallux Rigidus and Hallux Flexus (Fig. 256).—These terms indicate two stages of an affection of the metatarso-phalangeal joint of the great toe first described by Davies Colley. In the earlier stages—hallux rigidus—the great toe is stiff and incapable of being dorsi-flexed. Plantar-flexion is, as a rule, less restricted. In some cases the joint, in addition to being stiff, is painful, sensitive and swollen—hallux dolorosus.

As the disease progresses the toe is drawn towards the sole and becomes permanently flexed—hallux flexus—and any attempt at dorsi-flexion is attended with pain.

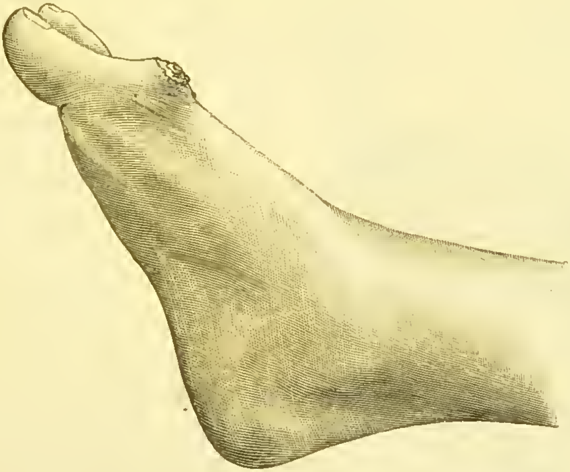

Fig. 256.—Hallux Rigidus and Flexus in a boy æt. 17. There is a suppurating corn over the head of the first metatarsal bone.

The condition is chiefly met with in adolescent males, is very commonly associated with flat-foot, and is then usually bilateral. The patient's gait, in addition to having the characteristic features associated with flat-foot, is peculiarly wooden and inelastic, as instead of rising on the balls of the toes with each step, he puts down and lifts the sole as if it were a rigid plate. The pain is increased by walking. The boot tends to become worn away at the point of the toes and at the posterior edge of the heel, and the usual crease across the dorsum is absent.

On dissection it is found, especially in hallux flexus, that the inferior portions of the lateral ligaments are contracted, and that the cartilage of that part of the head of the metatarsal which is exposed on the dorsum is converted into fibrous tissue. Bony ankylosis has not been observed.

Treatment.—In early cases great benefit results from measures directed towards the cure of the accompanying flat-foot. If the joint of the big toe is painful and sensitive, absolute rest should be enforced until these symptoms have disappeared. The patient must wear a properly shaped boot with a pliable sole, and is then instructed how to manipulate and exercise the toe. When the toe is already rigid or flexed towards the sole, the above treatment is not feasible. The suffering may be relieved by inserting in the boot a rigid metal plate which will prevent any attempt at dorsi-flexion in walking. The deformity may be corrected under anæsthesia by wrenching the toe into the dorsi-flexed position, or where this is impossible, by excising a wedge from the dorsal aspect of the metatarsal bone immediately behind its articular surface.

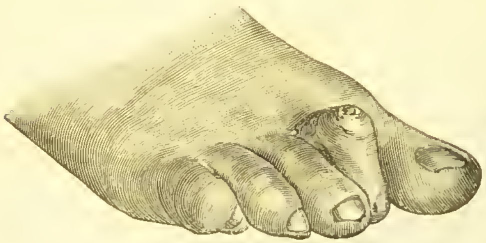

FIG. 257.—Hammer-toe.

Hammer-toe.—This is a flexion-contracture which usually involves the second, but sometimes also other toes. It is sometimes congenital and inherited, but usually develops about puberty, and is then, as a rule, bilateral.

The first phalanx is dorsi-flexed, the second is plantar-flexed, while the third varies in its attitude, sometimes being in line with the second, sometimes even more plantar-flexed, and sometimes dorsi-flexed. When the second toe is alone affected, as is commonly the case, it is partially buried by those on either side of it, only the knuckle of the first inter-phalangeal joint projecting above the level of the other toes. The skin over the head of the first phalanx being pressed upon by the boot usually presents a corn, under which a bursa forms. Both the corn and the bursa are subject to attacks of inflammation which cause considerable suffering and disability in walking. The soft parts at the distal extremity of the toe are flattened out by contact with the sole of the boot—hence the supposed resemblance to the head of a hammer.

On dissection it is found that the contracture depends on shortening of the plantar portions of the lateral ligaments and of the glenoid ligament upon which rests the head of the first phalanx. Although the extensor and the flexor tendons may also be shortened, their division does not permit of the deformity being corrected.

Hammer-toe is usually ascribed to the use of ill-fitting boots, especially those which are median-pointed and are too short for the feet. There appears to be an inherited predisposition to this deformity in some individuals.

Treatment.—While corrective manipulations, strapping, and the use of splints may be of service in slight cases, it is usually necessary to perform an operation in order to extend the toe permanently. The antiseptic preparation of the part must include the application of pure carbolic acid to any discharging sinus in relation to the corn or bursa. The lateral and glenoid ligaments are divided subcutaneously; and if the toe can be straightened easily, the foot is secured to a poroplastic or metal splint moulded to the sole and provided with longitudinal slots opposite the intervals on either side of the toe affected. The toe is drawn down to the splint by passing a loop of cotton or elastic bandage round the toe and through the slots. In many cases the contraction of all the tissues on the plantar aspect, including the skin, prevents the toe being straightened even after division of the ligaments. It is then necessary to remove the head and neck of the first phalanx through a lateral incision. We have found this to be the most satisfactory method of treating hammer-toe; the results are excellent, and the patient is able to go about again at the end of a week. In aggravated cases, and when the patient desires to be rid of the toe, it should be amputated at the metatarso-phalangeal joint. A pad of cotton wool should then be worn in the vacant space to prevent the adjacent toes falling together and the development of hallux valgus.

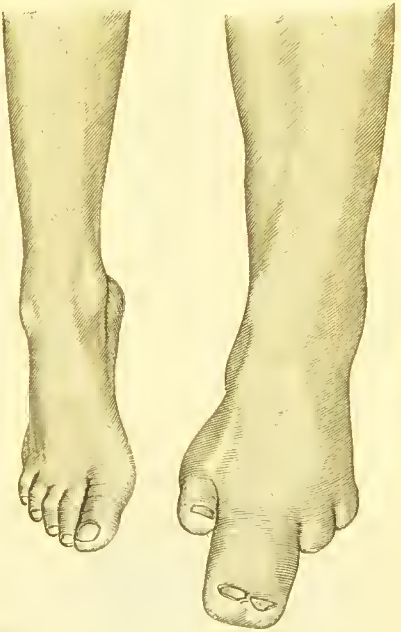

FIG. 258.—Congenital Hypertrophy of Left Lower Extremity in a boy æt. 5. The second and third toes are fused with one another.

Hypertrophy of the Toes.—One or more of the toes may be the seat of hypertrophy or local giantism. This is usually present at birth or appears in early childhood, and may form part of an overgrowth involving the entire lower extremity (Fig. 258). The overgrowth may involve all the tissues equally, or the subcutaneous fat may be specially affected. The inner toes are those most commonly hypertrophied. In addition to the enlargement, the toe may be displaced from its normal axis. The hypertrophy may affect two or more toes which are fused together or webbed. The treatment consists in amputating as much of the toe as will allow of the patient wearing an ordinary boot.

Supernumerary Toes (*Polydactylism*).—These vary from mere appendages of skin to fully developed toes. If they interfere with the use or appearance of the foot, they may be removed.

Webbing of the Toes (*Syndactylism*).—This may affect two or more of the toes, and it varies from a condition in which they are merely united by a web of skin to one in which they are so completely fused that the individual digits are only indicated by the nails. The degree of fusion is readily shown by means of skiagrams. Unless associated with congenital hypertrophy no treatment is called for.

DEFORMITIES OF THE UPPER EXTREMITY.

Congenital Absence of the Clavicle.—Both clavicles may be absent without there being any noticeable deformity or impairment of function. In such cases it is possible for the patient to bring his shoulders into contact with one another in front of the chest.

Displacements of the Scapula.—Mention may first be made of the *congenital upward displacement* of this bone. The one shoulder appears higher than the other, the trapezius is prominent, and the dorsal spine is convex to the affected side. In addition to the upward displacement the scapula is also tilted so that its inferior angle approaches the spine and its axillary border is nearly horizontal. It is sometimes associated with imperfect development of the lower part of the trapezius. When the functions of the arm are not interfered with there is no indication for treatment. When, however, abduction is seriously restricted as a result of the posterior superior angle of the bone coming into contact with the transverse processes of the cervical vertebrae, this angle of the bone may be removed.

Winged Scapula.—This condition consists in a marked displacement backwards of the lower angle and vertebral border of the scapula, when the patient attempts by using the deltoid to raise the arm from the side (Fig. 259). Under normal conditions, in making this movement the serratus magnus and rhomboid muscles pull forward the vertebral border and inferior angle of the scapula, and so fix the bone firmly against the chest wall. When these muscles are paralysed, as a result of infantile paralysis, neuritis, or injury of the nerve of Bell, or of the fifth and sixth cervical nerve roots, through which they receive their supply, the patient is unable to abduct the arm, the deltoid having lost its *point d'appui*, and its contraction merely results in tilting the angle of the scapula backward.

The *treatment* consists in the administration of strychnine and other muscle and nerve tonics, and the use of massage and the faradic current. The application of a carefully adjusted padded belt is sometimes useful. A former method of treatment by stitching the latissimus dorsi over the lower angle of the scapula was based on the erroneous assumption that the displacement was due to the slipping of that muscle from off the bone, although it must be admitted that the operation sometimes diminishes the deformity and adds to the patient's comfort.

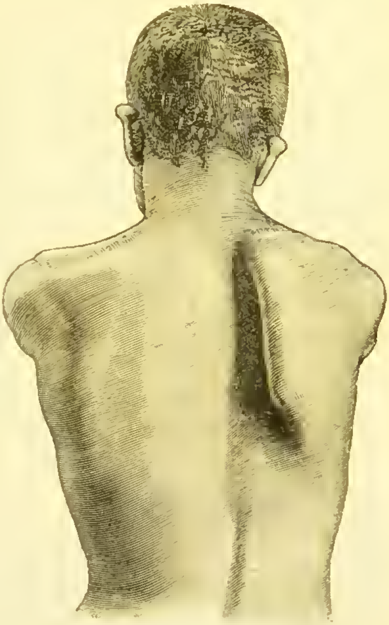

FIG. 259.—Winged Scapula.

Displacement of the scapula upwards and outwards, has been observed as a result of partial paralysis of the trapezius when the spinal accessory nerve has been divided in removing tuberculous glands from the neck. In these acquired displacements treatment is directed towards the nerve lesion and towards the improvement of the muscles by electricity, massage and exercises.

Congenital Dislocation of the Shoulder.—This is a very rare condition. It is usually bilateral and associated with other congenital defects. The dislocation may be subcoracoid, subacromial or subspinous. The glenoid cavity is deformed or absent altogether. The movements of the arm are restricted, and the development of the extremity as a whole is interfered with. The treatment consists in reducing the dislocation by manipulation, or, if this fail, by operation.

Paralytic Deformities of the Shoulder—Paralytic Dislocation.—The muscles in the region of the shoulder may have their innervation interfered with as a result of various conditions, of which infantile paralysis and injuries of the brachial plexus at birth are the most important. The capsular ligament of the shoulder-joint being no longer kept tense by the scapular muscles —especially the deltoid and external rotators—becomes relaxed, and is stretched by the weight of the arm. The appearances are characteristic. The muscles of the shoulder are wasted, the acromion is prominent, and between it and the upper end of the humerus there is a marked hollow into which one or more fingers may be inserted. The arm hangs flaccid by the side and may be moved in a flail-like fashion in all directions, the patient having very little control over it. The treatment consists in fixing the upper arm to the trunk by some form of apparatus, or in bringing about by operative means—arthrodesis—a close fibrous union between the humerus and glenoid, so that the movements of the scapula may be communicated to the upper arm and thus enable the patient to execute purpose-like movements.

Congenital Dislocations at the Elbow.—The head of the radius may be dislocated forwards, backwards or outwards—usually in association with imperfect development of the outer condyle of the humerus. As the displaced head of the bone interferes with the movements at the elbow-joint, the best treatment is to excise it. Congenital dislocation of both bones of the forearm is extremely rare.

Cubitus Valgus and Cubitus Varus.—When the normal arm hangs by the side with the palm of the hand directed forwards, the forearm and upper arm form an angle which is open outwards—this is known as the "carrying angle"; it is usually more marked in women in association with the greater breadth of the pelvis. When this angle is exaggerated the attitude is described as one of *cubitus valgus* (Fig. 109). This deformity may be acquired as a result of rickets, but more commonly it is due to a fracture of the external condyle of the humerus, in which the separated fragment has been displaced upwards. Sometimes it is of congenital origin and is associated with great slackness of the ligaments.

Cubitus varus (Fig. 108) is the reverse of cubitus valgus. It is more common, and is nearly always a result of fracture of the lower end of the humerus or separation of the epiphysis and subsequent interference with growth. These deformities may be corrected by supra-condylar osteotomy of the humerus.

Deformities of the Forearm and Hand.—The radius may be partially or completely absent, frequently in combination with other malformations. The most evident result is a deviation of the hand to the radial side—one variety of *club-hand* (manus vara). The forearm is shortened, the ulna is thickened and often bent, the thumb and its metacarpal bone are often absent, and the usefulness of the hand and arm is greatly impaired. For its treatment Bardenheuer has devised an operation which consists in splitting the lower end of the ulna longitudinally and inserting the proximal end of the carpus into the cleft. Congenital deficiency of the ulna is extremely rare.

A deformity resembling congenital club-hand is brought about when the growth of either of the bones of the forearm has been arrested as a result of disease or of traumatic separation of its lower epiphysis. The hand deviates to the side on which the growth has been arrested. The treatment consists in resecting a portion of the longer bone. The deformities of the forearm which result from fractures have already been considered.

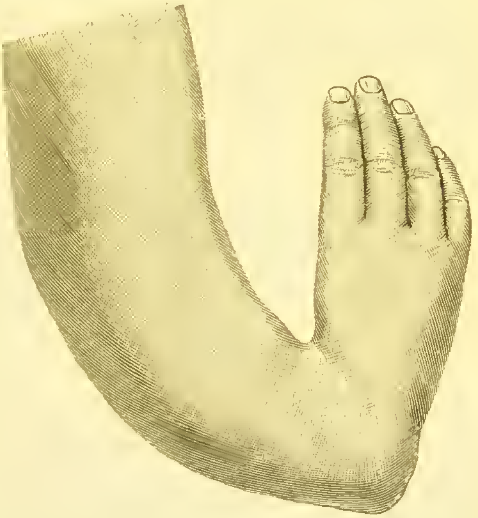
FIG. 260.—Club-hand, the result of imperfect development of radius. The thumb is absent.

(From a cast in Mr. Annandale's collection.)

Congenital Contracture of the Wrist—Club-hand Proper.—This very rare deformity corresponds to congenital club-foot and probably arises in the same way. The appearances resemble to a certain extent those of paralysis of the musculo-spiral nerve. The hand and fingers are rigidly flexed to the ulnar side so that the patient is incapable of moving them. Treatment is carried out on the same lines as for club-foot.

Spontaneous Subluxation of the Wrist.—This is an acquired deformity met with between the ages of fifteen and twenty-five, chiefly in females who follow trades which entail hard manual labour. The gradual relaxation of ligaments allows the flexors to displace the carpus towards the palm, while the lower ends of the bones of the forearm project on the dorsum. The usefulness of the hand is greatly impaired. In treating this condition the patient must give up her occupation for a time and persevere with a course of massage, electricity and exercises.

Congenital dislocation of the wrist is excessively rare.

Deformities of the Fingers.—*Congenital dislocations* of various forms are met with, but are of little clinical importance as they interfere but slightly with the usefulness of the finger concerned.

Congenital lateral deviation of the phalanges is more unsightly than disabling; it is chiefly met with in the thumb, in which the terminal phalanx may deviate to the radial or to the ulnar side. The deviation disappears on flexion.

Congenital contraction of the fingers is comparatively common. It is an inherited deformity, and is often met with in several members of the same family. It most frequently affects the little or the ring and little fingers (Fig. 261). The second and third phalanges are flexed towards the palm while the first phalanx is dorsi-flexed, this being the reverse of what is observed in Dupuytren's contraction. The affection is usually disregarded in infancy and childhood as being of no importance. Its etiology is not known. In the first stage the deformity is easily corrected by the child wearing a light splint fixed with strips of plaster, or a piece of whalebone or steel inside the finger of a glove. At a later stage, tense bands of fascia on the palmar aspect may require to be divided subcutaneously before it is possible to extend the finger. A retentive splint must be worn for a long period, at first night and day, and later during the night only.

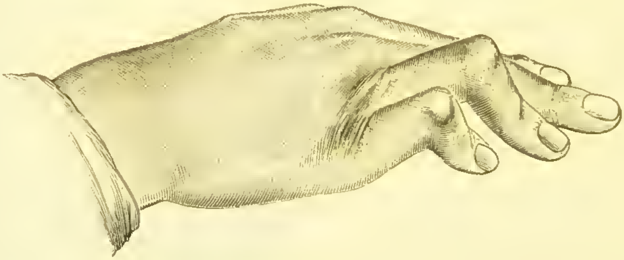

FIG. 261.—Congenital Contraction of Ring and Little Fingers.

Dupuytren's Contraction.—This is an acquired deformity resulting from contraction of the palmar fascia and its digital prolongations. It is rare in childhood and youth, but is common after middle life, especially in men. It is chiefly met with in those who are predisposed to it by inheritance or by gout, and in those who are liable to arthritis deformans. While sometimes seen in the working classes and attributed to the pressure of some hard object on the palm of the hand—such as a hammer or shovel or whip—its greater frequency in those who do no manual work, and the fact that it is very often bilateral, indicate that the constitutional factor is the most important in its etiology.

Although advice is rarely sought until the finger has become flexed, in the initial stage there is a well-marked induration in the palm opposite the metacarpo-phalangeal joint, and the skin over it is puckered and closely adherent to the underlying fascia. After a variable interval, the finger is gradually and progressively flexed at the metacarpo-phalangeal joint. The ring finger is usually the first to be affected, less often the fifth, although both are very commonly involved. It is rarest of all in the index. The flexion may be confined to the metacarpo-phalangeal joint, or the middle and distal phalanges may also be flexed; and as the deformity becomes more pronounced, the nail of the affected finger may come into contact with the skin of the palm. Dissections show that the flexion of the finger is the result of a chronic interstitial overgrowth and subsequent contraction of the palmar fascia and of its prolongations on to the sides of the fingers. The digital processes of the fascia are thickened and shortened and come to stand out like the string of a bow. The adipose tissue in the skin of the palm atrophies and disappears, and the skin and fascia thus brought into contact become fused with one another. The tendons and their sheaths are not implicated; they are found lying deeply in the concavity of the curve of the flexed digit. The condition is easily diagnosed from the congenital contraction by the fact that in the latter the proximal phalanx is extended or hyper-extended.

Treatment.—If seen at the stage of induration in the palm, contraction may be prevented by passive movements of the finger and by massage of the indurated fascia. When flexion has already occurred it is most easily corrected by what is known as Adam's operation. This consists in multiple subcutaneous division of the contracted fascia in the palm and of its prolongations on to the finger. In addition to dividing the fascia, the tenotomy knife should also be used to separate the skin from the fascia. The finger is then forcibly extended and a well-padded splint is secured to the hand and forearm. The skin on the palmar aspect opposite the first inter-phalangeal joint may give way when the finger is extended; should this occur the resulting gap should be filled up by a Thiersch graft. The after-treatment consists in massage and passive movements, and a splint may be worn at night until there is no longer any tendency to recontraction. In recent years excision of the affected portions of fascia has been successfully practised, and although a tedious operation it yields satisfactory and permanent results.

Supernumerary Fingers (Polydactylism).—These may coexist with supernumerary toes, and the condition is often met with in several members of the same family. The extra finger may be represented by a mere skin appendage the nature of which may only be indicated by the presence of a rudimentary nail, or by a more or less perfectly formed finger. In the majority of cases it should be removed.

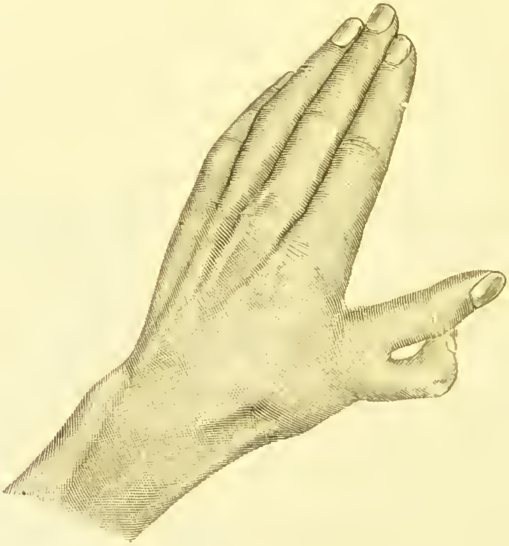

Fig. 262.—Supernumerary Thumb.

Congenital Deficiencies in the Number of Fingers.—One or more fingers may be entirely absent, such deficiency being often associated with imperfect development of the hand and forearm, or they may be represented by short rounded stumps, these being usually ascribed to the strangulation of the digits by amniotic bands *in utero*—the so-called intra-uterine amputation.

Webbing of Fingers (Syndactylism).—Congenital webbing or fusion of the fingers may be associated with polydactylism or with congenital hypertrophy, and, like other digital deformities, may affect several members of the same family. The degree of fusion ranges from a web of skin joining the fingers to a growing together of all the tissues. The participation of the bones is well shown in skiagrams. The separation of webbed fingers by surgical means must be considered in relation to the conditions present in each individual case. If an operation is decided upon it should be deferred until the age of five or six years, as the skin of young children is extremely sensitive to antiseptic applications and to pressure. In the simplest cases it is only necessary to divide the web and to unite the cut edges of skin along each finger by sutures, a Thiersch graft being inserted into the angle between the fingers. An operation in which the skin is dissected up in the form of flaps may be required.

Congenital Hypertrophy of the Fingers.—This is a form of local giantism affecting one or more digits, and involving all the tissues equally, or particularly the adipose tissue. The finger is usually of abnormal size at birth and continues to grow more rapidly than the others, and it may also come to deviate from its proper axis. Such a finger should be removed, as it interferes with the use of the other digits.

Trigger Finger.—This is an acquired condition in which movement of the finger, either in flexion or extension, is arrested, and is only completed with the assistance of the other hand. The obstacle to movement is usually overcome with a jerk or snap suggesting a resemblance to the trigger of a gun or the blade of a clasp-knife. It may arise from different causes, the commonest being a disproportion between the size of the tendon and its sheath. Recovery usually takes place under massage and passive movements.

The *drop* or *mallet finger* has been described with injuries of the fingers.

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